VEGETABLE GROWING

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PREFACE TO FIFTH EDITION

THE techniques of commercial vegetable growing change rapidly and differ widely from one part of the country to another. New types of labor-saving equipment are developed which in turn call for changes in methods of planting even to the use of new varieties designed to fit this new machinery. New materials and methods for weed and pest control continue to appear. These are constantly being evaluated by public agencies. Growers must maintain contact with such agencies in order to keep abreast of the latest tested information. The best that a book can hope to do is to indicate the current procedures and trends.

The fundamentals of plant growth remain the same and once they are understood the alert grower can modify his procedures with the changing times. Therefore this book has been prepared with the aim of presenting the characteristics of the crops, the factors affecting their growth, and the general considerations which must be observed in their culture.

In teaching a course in vegetable production the instructor should have two objectives in mind. One is to instill the knowledge of facts. The other, equally important, is to aid the student in developing judgment so that he will be equipped to deal with any situations or problems he may face and be able to make the proper decisions based on facts.

It has been necessary to present the facts with brevity in order to encompass the material in a book of this size. Repetition has been avoided except where essential. In the treatment of the individual crops the author has assumed that the chapters dealing with the more general phases have been mastered. The index has been made especially complete for reference purposes.

The technical and popular literature consulted in the preparation of this book is too voluminous to be cited in detail. Appended to each chapter is a selected list of publications which can form the basis of additional reading. At the end of the book are given the addresses of state and federal agencies from which publications may be obtained.

Grateful acknowledgment is made of the helpful suggestions from the author's colleagues and co-workers and from the teachers who have used the previous editions as a text for their courses.

J. E. K.

Davis, California.

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VEGETABLE GROWING

Part I. General Considerations

Chapter 1

VEGETABLE GROWING

In the olden days one who cultivated a garden was known as a horticulturist. This was in an inclusive sense as distinguished from the growing of field crops. His domain contained vegetables, fruits, flowers and ornamental shrubs. Modern specialization has made the term "horticulturist" applicable more particularly to the ornamental phases of plant growing. The production of vegetables, fruits and ornamentals is based on certain fundamental principles of plant growth and these fields of endeavor are faced with rather similar problems of marketing due to the perishability of many of their products. Aside from this their methods have little in common.

The vegetable industry has greater flexibility than the fruit industry. It has no long-time investment except in the case of the greenhouse operator. One can get into the vegetable business quickly, shift crops if any show indications of being over-produced, or put the land into a rotation with field crops. Financing of vegetables is usually on a short term basis and often is furnished by a dealer or shipper. While many vegetable producing areas have a long history, it is true that the relative permanence of fruit production in a district makes it easier to develop cooperative organizations among fruit growers than among vegetable growers.

Bailey has suggested that a vegetable is considered in the common usage of the term as the edible portion of an herbaceous annual or perennial. A fruit, on the other hand, is the product of a woody plant, except in the case of the strawberry. A distinction between the two is difficult. Formerly vegetables were cooked while fruits were used as a dessert. Now we eat many raw vegetables and have muskmelons and watermelons which are obviously of the dessert class. Botanically speaking, it is the fruit of tomato, pepper, eggplant, cucumber, muskmelon and others which constitutes their edible portion.

Importance.—The production and consumption of vegetables has increased greatly during the last thirty years. There are year to year

fluctuations. The trend is indicated best by the average area of land devoted to truck crop production for periods of several years. The average annual acreage for 21 of the leading truck crops grown for market and processing was 1,352,710 acres for the five-year period, 1919 to 1923. A decade later, 1929 to 1933 the average annual plantings of these crops was 2,599,630 acres. In the five-year period 1939 to 1943 the average annual acreage had risen to 3,289,240 acres and by 1949 to 1953 to 3,675,380 acres. There is now an additional annual planting of 60,000 acres of vegetables such as broccoli that were not among the 21 important ones in 1919.

During these same periods the average total annual acreages of potatoes and sweet potatoes harvested were 4,279,200; 3,941,400; 3,627,800 and 1,929,880 acres. The total supply of potatoes for consumption has remained relatively constant throughout this period of time due to increased acre yields resulting from improved cultural practices. The average acre yield of sweet potatoes on the other hand has changed little during the last four decades. The reduced plantings have therefore provided a decreased supply for consumers.

The figures given above indicate a radical change in our eating habits. Estimates of the per capita consumption of fresh vegetables show a rise from 100.7 pounds a year in 1919 to 146.0 pounds in 1954. The use of canned vegetables rose from 21.0 pounds per person a year in 1919 to 41.6 pounds in 1954. The eating of potatoes dropped from 150.0 pounds to 104.0 pounds and that of sweet potatoes from 29.1 to 8.1 pounds per person in a year during this 1919 to 1954 period. The per capita consumption of frozen vegetables was estimated to be 0.4 pounds a year in 1937. By 1954 it was 5.5 pounds.

Development of Types of Vegetable Growing in America.—In early Colonial days the family was more or less self-supporting. The *home garden* was the principal source of the fresh food supply, even as it is today on isolated farms. The city, suburban or farm garden is still a considerable factor in the total vegetable production of the country. The family garden may vary in size from the small city backyard, where there is room for just a few closely planted rows of quick growing vegetables, to the more extensive garden in the country. In the latter a great number of crops can be grown and the rows are spaced farther apart so that wheel hoe or horse cultivation can be used to control weeds. High quality is possible in the family garden. The farm garden may add to the farm income through sales to neighbors or at the roadside.

As people congregated in cities and towns, the gardens of those living on the outskirts were enlarged and the surplus peddled among the townspeople. This led ultimately to specialized vegetable production or *market gardening*. The industry is located relatively

close to market on small areas of high-priced land, where an intensive system of cropping, frequently under irrigation, must be followed to meet the high costs. A considerable number of different vegetable kinds are grown in order to have something to send to market through a larger part of the year. Much of the market gardener's time is devoted to selling his product.

Real estate operations have forced the abandonment of the older market gardening areas near many cities. Improved roads and vehicles have made it possible for the market gardener to locate 50 or more miles away from his market. By means of a fast motor truck he measures his distance in terms of driving time rather than mileage.

FIG. 1.—Cucumbers are an important greenhouse crop.

The market gardener found it desirable to keep in touch with his market the year round instead of reëstablishing connections as the growing season opened. This led him to storage of certain crops and enlargement of his plant-growing equipment into a greenhouse. Therefore, the *vegetable-forcing* industry, which is concerned with the production of vegetables out of season, usually developed near centers of consumption. Some forcing sections use coldframes rather than artificially heated glass structures. In the forcing of witloof chicory, rhubarb or asparagus, and the growing of mushrooms, cellars, caves and special sheds or houses are used. At the present time the greenhouse operator may or may not be also a market gardener.

Truck farming is the production of vegetables on an extensive scale. The location is determined by the soil and climatic factors favoring the culture of particular crops. The market may be within driving distance or hundreds of miles away. The cauliflower section of Long Island and the onion fields of Texas, both supplying New York City, illustrate this relation to market. The development of many of the truck-farming sections has been possible because their harvest comes at a time when the markets of the country are not completely supplied from some other source. An example is the sequence of potato crops beginning in Florida in early spring and moving up the Atlantic Coast until the late potato section of Maine is reached. Some of the high altitude and coastal districts of the West, because of cool temperatures, can produce head lettuce, cauliflower and peas in late summer when supplies elsewhere are scarce.

The word "truck" when used in describing this type of vegetable growing has no relationship to the motor truck. According to Webster's Dictionary it is derived from the French, "troquer," meaning "to barter." It has come to be applied to commodities raised for sale, that is garden truck.

Truck farming is specialized in that often but one kind of vegetable is grown. The land is relatively cheap, permitting a reduction of costs by large scale operations. Marketing is usually through shipping organizations, shippers or some other class of middleman.

Processing crop production is a scattered industry. Low cost of production of the raw product and efficient manufacture have been important factors in the extension of the industry in sections adapted to high yields of the particular crops. It is desirable for efficient operation of the cannery or freezing plant that a succession of different products should be available throughout the season. These may be either vegetables or fruits.

One state leads in the production of one crop, while another state is noted for a different processing crop. In recent years Wisconsin has led in the processing of sweet corn and peas, California in that of asparagus, spinach and tomato, while New York has been foremost with snap beans. Thirty-nine states have commercial acreages of one or more vegetables grown for processing.

Frequently the crop for canning is grown in the rotation of general farm crops. The canner contracts for a certain acreage with growers in the vicinity. The price is set with certain limitations on quality but is usually lower than the market price of fresh produce. Earliness is not a factor. The grower is assured of a market for his product so his aim is to get a large yield at a low-production cost.

The production of vegetables for preservation in the fresh-frozen condition is similar to production for the cannery. Gathering of the crop at the proper stage of maturity followed by rapid handling between harvesting and freezing is of utmost importance if a high quality frozen product is to be obtained.

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Fig. 2.—Harvesting artichokes grown where climatic conditions are especially favorable in the fog belt of California. The sand dunes at the ocean shore are visible in the background. (Courtesy California Agr. Ext. Service.)

Fig. 3.—The tomato is an important canning crop in a number of states. (Boyle.)

Considerable tonnages of vegetables are utilized annually for dehydration and for pickling.

The production of vegetable seeds is a rather specialized field of vegetable growing. Soil, climate and disease-free conditions are factors influencing the location of seed-growing areas. The labor requirements in the growing of certain kinds of seed may make their production in this country uneconomical. Carrot, lettuce and onion supplies are extensively produced in California. The seedsman furnishes the grower with stock seed to plant the number of acres contracted, and maintains rather careful supervision of the crop. Efficient production methods must be followed by the grower if he hopes to make the enterprise profitable.

Trends in Vegetable Growing.—The market garden with its numerous crops is giving way to the more extensive production of vegetables. The decrease in the number of horses in the cities has made more acute the manure problem of the market gardener. He has had to grow and plow under some green manure crops to replenish the soil organic matter. The number of cash crops is thereby reduced. Even near the markets many growers are concentrating on relatively few crops and striving to produce those more economically. Thus market gardening and truck farming are approaching each other in their present-day characteristics.

The vegetable forcing establishments in the East have met serious competition in the lettuce market from the Imperial, erroneously called Iceberg, varieties of lettuce produced in the West. These crisp head varieties are now a year-round commodity on the markets and the public is sometimes loath to change in the fall to the leaf or butter-head lettuce produced under glass. Radish, tomato and cucumber continue to be important greenhouse crops, as does also the production of vegetables and flower plants for local sale. Many of the smaller cities and towns offer a good market for greenhouse products, but increasing numbers of these are being supplied with fresh produce carried by wholesalers hundreds of miles in trucks from the larger cities which have terminal markets.

The development of the chain store has furnished consumers with fresh well-graded produce. Those people who used to pay cash at the farmers' market now do so at the chain store. If local growers hope to compete with distant shippers they must grade carefully and furnish the chain store or other retailer with a uniform product. Many of the vegetable shipments are inspected at the shipping points and certified according to certain standards set up by the U. S. Department of Agriculture, such as U. S. Fancy, U. S. No. 1, or U. S. No. 2. This work, which is carried on coöperatively by the Federal and State authorities, has had a wholesome effect on the uniformity and grading of produce from trucking sections. Informa-

tion can be obtained by application to one's State Bureau of Markets.

The eastern vegetable grower has the advantage of being located nearer the markets. He should be able to compete successfully with distant growers in those vegetables especially which are of higher quality if used soon after harvest, such as sweet corn and peas. The growing realization on the part of the public of the value of freshly harvested vegetables is a factor in the success of many well-located roadside markets.

Most vegetables are consumed in greater quantities from the fresh state than from the processed one. More Brussels sprouts and lima beans are used per person from the frozen than from the fresh or

Fig. 4.—Onion seed production in California. (Courtesy of Pieters-Wheeler Company.)

canned condition. The freezing of broccoli is increasing rapidly. The consumption of fresh peas is a poor third in comparison to that of the frozen and canned products. These trends all indicate that the consumer is interested in a quality product that will require a minimum of labor in its preparation for the table.

The self-service feature of the retail stores is bringing about a movement toward the packaging of fresh vegetables in consumer-size units. Carrots, celery, spinach and other crops are being packed either at the shipping point or at the terminal market, in cellophane or pliofilm bags and tomatoes in boxes with a transparent window.

Vegetable production is becoming increasingly mechanized. New machines are appearing that improve the work of soil preparation

and tillage, give more effective distribution of pesticides, or eliminate labor in harvesting operations. This trend is bound to continue.

Several hundred thousand acres of additional land must be put into use for vegetables in the next twenty-five years in order to keep pace with the growth in population of the United States.

On the whole vegetable growing should continue to assume importance as a profitable field of agriculture. The industry will be helped by better marketing methods; more economical production through increased knowledge of soil technology; improved varieties; better insect and disease control; the elimination of unnecessary operations; and use of labor-saving machinery.

Chapter 2

CLASSIFICATION OF VEGETABLES

SOME method of grouping different vegetable kinds is essential to an adequate understanding of their relationships. The number is great and the requirements of many so similar that the student will find it more easy to recall the cultural practices of a given crop if he first appreciates its relation to other and perhaps more common crops. The subject matter concerning the crops is presented later by groups having somewhat similar cultural requirements.

Vegetables could be classified according to the parts used for food: leaves—cabbage, lettuce, spinach, etc.; roots—carrot, beet, etc. A practical method of separating crops would be on their hardiness or resistance to spring frosts. The onion can stand light frosts while the cucumber cannot. Speed of growth or time to maturity could serve as a basis of classification. Radish and spinach mature quickly compared to potato, onion and squash. Classifications based on temperature requirements and on botanical relationships will be discussed in detail as they are the most useful.

CLASSIFICATION BY TEMPERATURE REQUIREMENTS.

Vegetables can be placed roughly into two groups according to their general temperature requirements. This is a practical and useful method of classification.

The line between the two groups is not clearly marked in as much as there are some cool season crops which can tolerate warm weather and make fairly satisfactory growth. Chard, collard, beet, carrot, onion, horseradish and others fall into this category. However, their quality may or may not be as good under warm conditions as under cool ones. Usually the temperatures prevailing as the cool season crops approach maturity are of greatest importance. Some of the cool season crops, notably the potato, cannot withstand frosts. Likewise within the warm season group crops like pepper and beans prefer somewhat lower temperatures than do other warm season crops.

The cool season crops grow well when monthly mean temperatures do not exceed about 70° F. They thrive best if the monthly mean is 60 to 65° F. The average monthly maximum should not exceed 80 to 85° F. nor the minimum go below 35 to 40° F. The warm season crops on the other hand do best when the monthly

mean and average maximum are about 10° higher than for the cool season crops. The average monthly minimum temperature should not be below 48 to 50° F. for the warm season crops. The *cool season* vegetables are those of which the vegetative parts—buds, leaves, stems or underground portions—are usually used as food. The exceptions that belong in this group are the pea and the broad bean. *Warm season* vegetables on the other hand are those of which we eat the fruiting parts. The exceptions to this rule are the sweet potato and New Zealand spinach.

There are several distinctions which may be made between these two groups. In general cool season crops are (1) hardy or frost

COOL SEASON VEGETABLES.

Asparagus	Chervil	Horseradish	Radish
Artichoke	Chicory	Kale	Rhubarb
Beet	Chinese cabbage	Kohlrabi	Rutabaga
Broad bean	Chive	Leek	Salsify
Broccoli	Collard	Lettuce	Scolymus
Brussels sprouts	Corn salad	Mustard	Scorzonera
Cabbage	Cress	Onion	Sea kale
Cardoon	Dandelion	Orach	Sorrel
Carrot	Endive	Parsley	Spinach
Cauliflower	Florence fennel	Parsnip	Spinach dock
Celery	Garlic	Pea	Turnip
Celeriac	Jerusalem artichoke	Potato	Watercress
Chard			

WARM SEASON VEGETABLES.

Cucumber	Okra	Squash
Eggplant	Pepper	Sweet corn
Lima bean	Pumpkin	Sweet potato
Martynia	Roselle	Tomato
Muskmelon	Snap bean	Watermelon
New Zealand spinach	Soybean	

tolerant, while warm season crops are tender or frost susceptible. Compared to warm season crops the cool season ones differ in that (2) their seeds will germinate in cooler soil, (3) the plants can absorb water better from cool soil, and (4) the harvested vegetables are stored at cooler temperatures, except for the warm season crop, sweet corn, which requires icing. If a hard pan does not interfere (5) the roots of most of the cool season vegetables will generally go to a depth of about 2 feet while those of many of the warm season crops penetrate 4 to 6 feet or more into the soil. A few of each group are intermediate. The perennial vegetables are deep rooted. Thus, because of their shallow root system the cool season crops (6) need more fertilizer especially nitrogen and (7) more frequent watering or rain than do the warm season ones.

Such a classification gives the grower the knowledge he needs to plan his planting operations for any time of the year if he knows the usual temperature conditions for his locality. It further provides him with a clue to some of the cultural requirements. Specific planting dates for a given crop are not a satisfactory criteria for vegetable operations because they vary by about a week for each 100 miles of latitude. Moreover, elevation and the presence of large bodies of water modify climates. In some sections of the country planting must be delayed until the ground thaws out in the spring. In other areas the seeds will germinate and the young plants make some growth during the winter months.

Knowing the distinction betwen cool and warm season crops leads next to an association of the crops in each catagory into smaller groups each one of which has certain general characteristics or production procedures. Thus we can separate the root crops, salad crops, bulb crops, cole crops, vine crops and others for separate consideration. In the crop chapters later the cool season crops are discussed first and then the warm season crops.

BOTANICAL CLASSIFICATION.

Botanists using structural characteristics have classified all plants into four main groups. Vegetables are in the fourth group–the Spermatophytes, or seed plants, and in the second division, the Angiosperms of that group. Plants are separated further as to class Monocotyledoneae or Dicotyledoneae, on the basis of one or two cotyledons in their seeds, and then by family, genus, species, and subspecies or botanical variety. For example sweet corn belongs to the family Gramineae, the genus Zea, the species Mays, and the botanical variety rugosa. Vegetables are commonly classified further as to horticultural variety and strain. With sweet corn this might be Golden Cross and T strain.

It is the family relationships in the botanical classification which are of greatest importance in so far as vegetable growing is concerned. The seeds of the vegetables within a family may be somewhat similar in size and shape. This helps one know the proper depth of planting, and the type of seedbed preparation needed. Usually the members of the same family are susceptible to attack by the same insect or disease so the grower can be on guard. The foliage of the members of the Parsley family is tolerant of oil. Knowing which they are permits one to plan on using an oil spray to kill weeds in such crops.

Botanical works differ slightly in the names given to certain vegetables. The following classification adapted from Bailey's "Manual of Cultivated Plants" includes the more important vegetables. It has been modified in some respects to conform with recent taxanomic studies and the international methods of nomenclature.

BOTANICAL LIST OF THE VEGETABLE CROPS GIVING FAMILY, GENERIC AND SPECIFIC NAMES.

Monocotyledoneae		
Gramineae—Grass Family		
Zea mays	var. rugosa	Sweet corn
Liliaceae—Lily Family		
Asparagus officinalis		Asparagus
Amaryllidaceae—Amaryllis Family		
Allium sativum		Garlic
Allium porrum		Leek
Allium fistulosum		Welsh onion
Allium ascalonicum		Shallot
Allium schoenoprasum		Chive
Allium cepa		Onion
Allium cepa	var. aggregatum	Potato onion
Allium cepa	var. viviparum	Top onion
Dicotyledoneae		
Polygonaceae—Buckwheat or Knotweed Family		
Rheum rhaponticum		Rhubarb
Rumex acetosa		Garden Sorrel
Rumex patientia		Spinach dock
Chenopodiaceae—Goosefoot Family		
Beta vulgaris		Beet
Beta vulgaris	var. cicla	Swiss chard
Atriplex hortensis		Orach
Spinacia oleracea		Prickly-seeded spinach
Spinacia oleracea	var. inermis	Round-seeded spinach
Aizoaceae—Carpet-weed Family		
Tetragonia expansa		New Zealand spinach
Cruciferae—Mustard Family		
Brassica oleracea	var. acephala	Kale, borecole, collard
Brassica oleracea	var. gemmifera	Brussels sprouts
Brassica oleracea	var. capitata	Cabbage
Brassica oleracea	var. botrytis	Cauliflower
Brassica oleracea	var. italica	Sprouting broccoli
Brassica oleracea	var. gongylodes	Kohlrabi
Brassica napus	var. napobrassica	Rutabaga
Brassica napus	var. pabularia	Siberian kale
Brassica campestris	var. rapa	Turnip
Brassica ruvo		Broccoli-raab
Brassica juncea		Leaf mustard
Brassica juncea	var. crispifolia	Southern curled mustard
Brassica hirta		White mustard
Brassica perviridis		Spinach mustard
Brassica pekinensis		Pe-tsai Chinese cabbage
Brassica chinensis		Pak-choi Chinese cabbage
Barbarea verna		Upland cress
Nasturtium officinale		Watercress

Dicotyledoneae—*Continued.*

Armoracia rusticana		Horseradish
Lepidium sativum		Garden cress
Raphanus sativus		Radish
Crambe maritima		Sea kale
Leguminosae—Pea or Pulse Family		
Pisum sativum		Garden pea
Pisum sativum	var. macrocarpon	Edible podded pea
Vicia faba		Broad bean
Phaseolus vulgaris		Kidney or common bean
Phaseolus vulgaris	var. humilis	Bush bean
Phaseolus coccineus		Multiflora or scarlet runner bean
Phaseolus coccineus	var. albus	White Dutch runner
Phaseolus lunatus		Lima bean
Vigna sinensis	var. sesquipedalis	Asparagus or yard-long bean
Vigna sinensis		Cowpea
Glycine max		Soybean
Malvaceae—Mallow Family		
Hibiscus esculentus		Okra
Hibiscus sabdariffa		Roselle
Araliaceae—Ginseng Family		
Aralia cordata		Udo
Umbelliferae—Parsley Family		
Daucus carota	var. sativa	Carrot
Foeniculum vulgare		Fennel
Foeniculum vulgare	var. dulce	Florence fennel
Petroselinum crispum		Parsley
Petroselinum crispum	var. tuberosum	Turnip-rooted or Hamburg parsley
Apium graveolens	var. dulce	Celery
Apium graveolens	var. rapaceum	Celeriac
Pastinaca sativa		Parsnip
Anthriscus cerefolium		Salad chervil
Convolvulaceae—Morning Glory Family		
Ipomoea batatas		Sweet potato
Solanaceae—Nightshade Family		
Solanum tuberosum		Potato
Solanum melongena		Eggplant
Lycopersicon esculentum	var. commune	Common tomato
Physalis pruinosa		Husk tomato
Capsicum annuum		Bell or sweet pepper
Capsicum frutescens		Tobasco pepper
Martyniaceae—Martynia Family		
Proboscidea jussieui		Martynia
Valerianaceae—Valerian Family		
Valerianella locusta	var. olitoria	Corn salad
Cucurbitaceae—Gourd Family		
Cucurbita pepo		Pumpkin and winter squash

BOTANICAL LIST OF THE VEGETABLE CROPS GIVING FAMILY, GENERIC AND SPECIFIC NAMES.—(*Continued.*)

Dicotyledoneae—*Continued.*

Cucurbita pepo	var. melopepo	Bush summer squash
Cucurbita pepo	var. medullosa	Zucchini and marrow squash
Cucurbita moschata		Pumpkin and winter squash
Cucurbita maxima		Winter squash
Cucurbita mixta		Pumpkin
Citrullus vulgaris		Watermelon
Cucumis anguria		West India gherkin
Cucumis sativus		Cucumber
Cucumis melo	var. reticulatus	Netted muskmelon
Cucumis melo	var. inodorus	Winter or cassaba melon
Sechium edule		Chayote
Compositae—Composite Family		
Cichorium intybus		Chicory
Cichorium endivia		Endive
Scolymus hispanicus		Spanish oyster plant
Scorzonera hispanica		Black salsify
Tragopogon porrifolius		Salsify
Taraxacum officinale		Dandelion
Lactuca sativa	var. crispa	Leaf lettuce
Lactuca sativa	var. capitata	Head lettuce
Lactuca sativa	var. longifolia	Cos or romaine
Cynara cardunculus		Cardoon
Cynara scolymus		Artichoke
Helianthus tuberosus		Girasole or Jerusalem artichoke

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Chapter 3

FACTORS AFFECTING PLANT GROWTH

In order to grow vegetables properly an understanding of the principles of plant growth is helpful.

High quality should be the constant aim whenever vegetables are grown. In some respects, particularly as relates to flavor, the matter of quality is more or less a question of individual taste. The other contributing factors to quality such as tenderness, succulence, sweetness and the like, are easily recognized by all of us. Tough, bitter lettuce does not invite a second bite. A snap bean of the stringless type which does not have strong fibers in the side walls provides more enjoyable eating than does a variety which has these fibers. Unfortunately, high quality varieties of some vegetables do not always stand up well on the market. With the tremendous increase in the production of vegetables hundreds of miles from their ultimate market, varieties are in use which are adapted to withstand this shipping and handling. Thus the grower has the opportunity of having for his own consumption a much better product than does the person who must buy his supply on the market. In either case there are two groups of factors which operate to affect the ultimate condition of the produce when preparation for the table begins.

The first is concerned with the conditions affecting the crop while it is growing. The second includes those under which the product is kept during the interval between harvest and use. The shorter the time from garden to pot the less chance there will be for changes to take place. All that is thus gained may, of course, be lost by poor cooking.

The analysis of the tissues of a vegetable plant will indicate two very important points, namely: the high percentage of water, especially in the leafy vegetables like celery or lettuce, and the relatively small amount of minerals. Let us take for example cabbage, of which practically all the growth above the ground can be eaten. It may contain 91.5 per cent water, 7.5 per cent organic material, and 1 per cent mineral salts. If the plant is burned, most of its substance is driven off as water and carbon dioxide and only an ash remains. This ash contains most of the minerals which the plant has drawn from the soil. Besides this, the plant has absorbed water through its roots. The organic material represents combinations of the carbon dioxide obtained from the air. Thus it is apparent that the greater part of the solid matter in the plant is not drawn

from the soil but is made in the plant tissues themselves. The process of combining carbon dioxide and water into sugars is known as *photosynthesis.* It takes place in the leaves. Any practice, such as defoliation or pruning of the top growth of a plant must of consequence reduce the manufacturing area and check growth. Therefore any discussion of the factors affecting plant growth centers around their influence on the photosynthetic process. Continued growth is dependent upon new supplies of organic compounds built up in the plant.

Light.—The small green chloroplasts in the cells of the plant obtain their energy from the sunlight for combining carbon dioxide and water into sugars. Only a small percentage of the sunlight striking the leaf is used in the process, but the heat effect of the remainder plays an important part in speeding up the chemical reactions in the plant which are concerned with growth and maturity. The temperature of leaves in sunlight may be 5 to 15° F. above that of the air.

The part of the spectrum which is made up of the yellow to red waves is most effective in furnishing energy for photosynthesis. All the visible rays seem to exert an effect on the type of growth. The ultraviolet rays which are invisible and of very short wave length are not necessary for plant growth, though they may exert considerable influence on the type of growth. These shorter wave lengths cannot penetrate ordinary glass and they do not seem to be as necessary for plants as for animals.

Light is necessary for the formation of the green coloring matter contained in the plastids as are also sugar, magnesium and nitrogen. Iron is necessary but it does not enter into the composition of this chlorophyll molecule.

Light has still another effect on the type of growth. The number of hours of daylight may determine whether the crop will develop as the grower desires or whether it will "bolt to seed" and pass out of an edible and salable condition. Some of the vegetable crops are "long-day" plants. They produce their seedstalks only when they are exposed to the days of late spring and summer which are more than twelve hours of daylight in length. Varieties of the same vegetable differ in the rapidity with which they go to seed. For example, the Virginia Savoy spinach is scarcely suitable for spring seeding, because it produces a seedstalk quickly in the long days of late spring. Whether a plant will be reproductive or vegetative in response to length of day is conditioned by temperature.

The initiation of bulbing of onions is determined by length of day modified somewhat by temperature. Some varieties will bulb in a twelve-hour day, while others require fourteen hours or more of light.

Carbon Dioxide.—The plant obtains most of the carbon used in the manufacture of sugars in the form of carbon dioxide from the air. At night or even when light intensity is very low, the plant loses carbon dioxide into the air instead of taking up some of this gas. This loss is the result of plant *respiration*. The supply of carbon dioxide available in the air is very low, since it constitutes only about 0.03 per cent of the volume of the air around the plant. This varies somewhat, being greater near the ground due to the rise of the gas liberated in the decomposition of organic matter in the soil. Lundegårdh has suggested this as one of the beneficial effects of the use of manure in hotbeds and greenhouses. When other conditions for rapid growth of the plant are ideal, it has been found that increased supplies of carbon dioxide have resulted in increased growth. The use of decaying manure has been the most effective means of increasing the carbon dioxide supply.

The toxic effect of poorly aërated soils is believed due to the high concentration of carbon dioxide in the soil. This interferes with the absorption of water and nutrients by the roots.

The gas passing into the plant goes into solution and diffuses into the cells which contain the chlorophyll-bearing plastids. Here, with water and the energy picked up from the light by these little chloroplasts, the carbon dioxide undergoes a change. Possibly after the production of several intermediate compounds, the carbon appears combined in some soluble primary sugar such as glucose.

Then the sugar passes out into other parts of the plant where it is changed into other organic compounds, depending on the conditions in the locality where it arrives. Some may be broken down into water and carbon dioxide, again releasing energy that can be used to build up other sugar particles into some of the complex organic or carbon-containing constituents of the plant. Fats, sucrose, starch, cellulose, gums, or proteins, or the complex protoplasm itself may be the destined use for the carbon from the original carbon dioxide. Sometimes these will break down, maybe not until the vegetable is eaten, and then once more the carbon atom goes on its way to new uses.

Moisture.—The greater part of the plant tissue in its fresh state is composed of water. If it is possible to say that any factor is the most essential one for growth, then water is that one. Not only is water used in the process of manufacturing the carbohydrate materials of the plant but it might be said to form the backbone of the whole plant structure.

Just back of the cap or sheath of a young growing root are little hairs which impart a fuzzy-like appearance to several millimeters of this section of the root. The hairs come in closer contact with the film of water about the soil particles than the roots would. As the older ones die off corky cells are developed on the surface which

then practically ceases to absorb. The check to a plant when it is transplanted is largely due to breaking off or death to the young roots with their root hairs.

The water passes through the protoplasmic lining of cells by *osmosis,* from the place where it is present in greatest amount to the region where it is least plentiful. It moves up through the plant, producing turgor in the stems and leaves. At the growing points the expanding of the young protoplasm-filled cells by the inward movement of water and newly manufactured products allows growth to take place. The cells in their turgid condition may be likened to a toy balloon taut with gas. If the gas particles escape and no others come to replace them the balloon collapses. Similarly the plant wilts if water is evaporated into the air and no more is supplied.

The leaves of the plants are spotted with multitudes of small openings called *stomates.* These openings connect with air chambers inside the leaf which become saturated with water vapor evaporating from the surfaces of the living cells. The carbon dioxide and oxygen of the air dissolve in the moist film on the surface of the cells. If it is warm, dry and windy, the rate of water loss, or *transpiration,* from the leaf may be greater than the entrance through the root. Then the plant wilts and these stomates close. Not only does the upward growth and expansion cease because of lack of turgor, but with the stomates closed and the carbon dioxide supply reduced, the manufacture of sugars is materially interrupted and growth is retarded. Thus the structure of the leaf which is favorable to the process of photosynthesis leads also to the inevitable loss of water and the possibility of a check in growth. Therefore an adequate supply of water to replace that lost, or a high humidity to prevent loss, is of great importance in obtaining rapid growth.

The sugars made by the tissues containing chlorophyll are moved in a soluble form to other parts of the plant. Ringing or girdling of the stem by injury or disease in such a way as to prevent the upward or downward movement of the food products will retard seriously the growth of the plant. If the roots cannot obtain supplies of sugar for forming new tissues, the absorption of water and minerals is reduced and the top growth suffers.

The sugars move readily through the conducting tissues as long as the plant is well supplied with water. When the moisture content is low, cell growth is stopped and materials are not utilized rapidly at the end of their journey; a traffic jam results which is felt back at the starting point. The accumulation there of the newly made sugars retards the manufacture of any more. Tissues then become tough through excessive production of cellulose and storage products. Compounds may be produced also which impart bitterness to the vegetable.

The mineral elements dissolved in the soil solution diffuse into the root and are distributed through the plant. They are essential but not in very large amounts.

Vegetables differ in their reaction to shortage of moisture. When the supply is abundant a more rapid and succulent growth will result. In general the so-called salad vegetables will be of higher quality, earlier maturity and better size if they are constantly supplied throughout their growth with sufficient moisture.

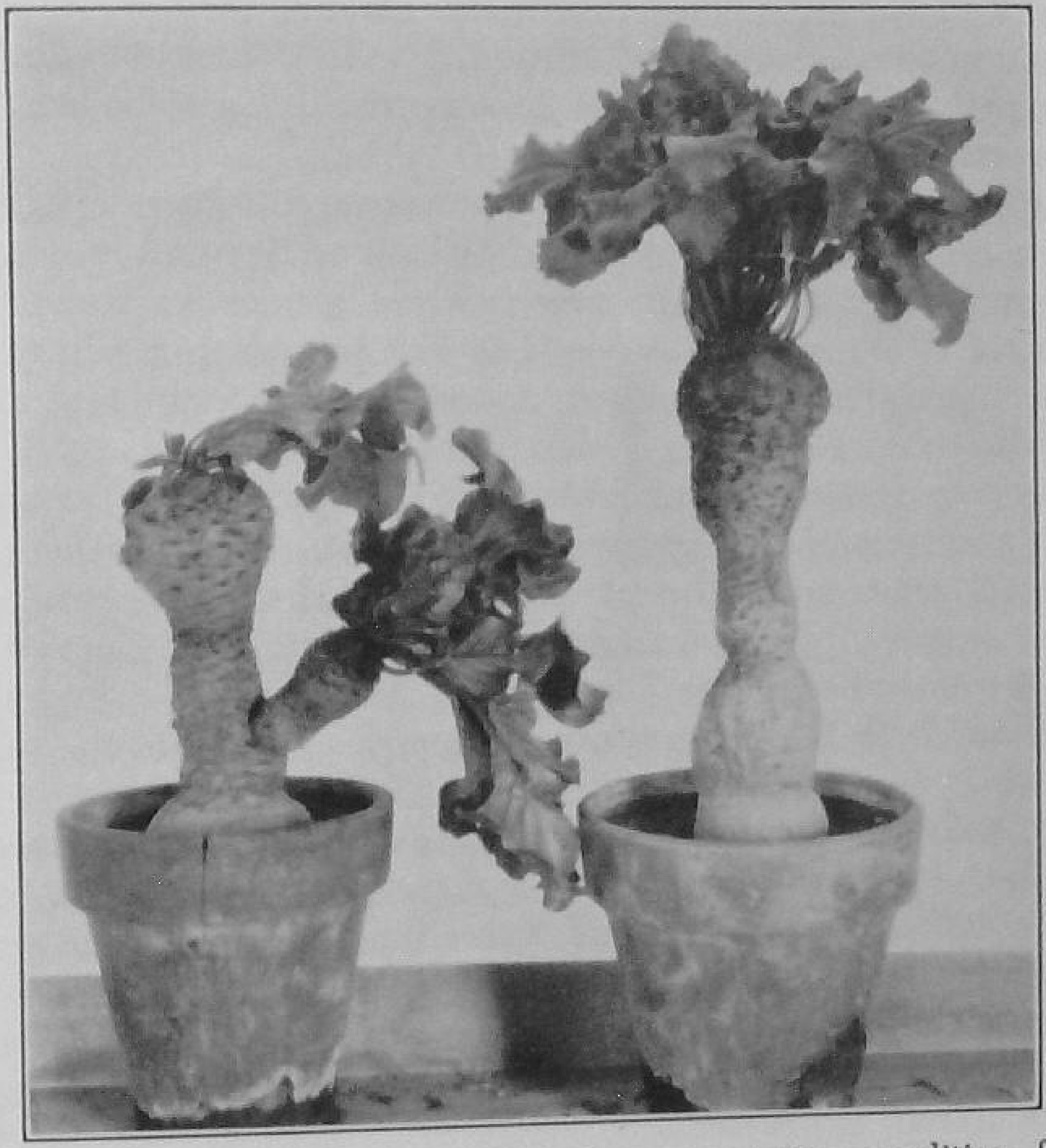

FIG. 5.—These beets have been kept in a vegetative condition for four seasons by growth at temperatures above 60° F. (Courtesy Cornell Univ. Agr. Exp. Sta.)

Temperature.—Many vegetables are very specific in their temperature requirements. Lima beans and sweet potatoes will make poor growth unless the weather is warm, and are killed by light frosts. Parsnips, on the other hand, will grow well during the heat of summer and will also withstand freezing if left in the ground all winter. Low temperatures close to the freezing-point improve the quality of parsnips by favoring a change from starch to sugar. A similar change in white potatoes brought about by temperatures just above freezing make them sweet and of less value to man.

High temperature increases the rate of water loss especially if the humidity is low, and also increases the rate of food utilization. At night and on cloudy days, light is the limiting factor for photosynthesis. On sunny days carbon dioxide usually limits the process. Temperature is rarely the limiting factor except at 50° F. or below. Thus, high temperature seldom increases food manufacture.

In warm weather peas and corn quickly pass through their most desirable stage of maturity and deteriorate very rapidly in quality as judged by decrease in sugar, increase in hemicelluloses and starch, and accompanying toughness. At high temperatures potatoes will not store much food in the tubers as the carbohydrates may all be used in respiration in the above-ground tissues of the plant or translocation may be retarded.

Low temperatures also exert influences on plants which are undesirable from a production point of view. Biennial crops such as celery, cabbage, and beets may produce seedstalks the first year instead of edible parts if exposed to low temperatures in the early stages of growth. Tomatoes do not set well if night temperatures drop below 59° F.

When the fruits of warm season vegetables, such as cucumbers, squash and tomato are exposed to temperatures below 50° to 55° F. while still attached to the plants in the field they may be predisposed to poor ripening and early breakdown after harvest. This effect is referred to as "chilling injury." It seems to be accumulative and related both to the duration of the exposure and to the temperature level.

Low soil temperatures may have an important effect on the absorption by the roots of water and nutrients. A plant in a moist soil may wilt from rapid loss of water from the top if the soil temperature is such as to reduce root activity.

Mineral Supply.—Minerals are essential for the growth of vegetables. Some are needed in relatively large quantities while only a trace of others is sufficient.

The supply of these minerals in the soil is dependent on: *(a)* The amount added in readily available form in commercial fertilizers; *(b)* the liberation of those naturally present in the soil by the action of acids formed in the decomposition of organic matter; *(c)* the action of nitrifying bacteria in making the nitrogen of the air available for absorption by the plant. The nitrates formed in this manner may be lost by leaching in the lighter soils or may be used by other bacteria in breaking down organic materials such as sod and cover crops when these are plowed into the soil. A low temperature or presence of excess moisture will seriously retard or even stop the action of nitrifying bacteria and the plant growth will be checked. A considerable growth of weeds among vegetables will provide too much competition, because of use of water and nutrients, especially nitrates, by the weeds.

Nitrogen, phosphorus, potassium and calcium are usually considered of greatest importance for plant growth and most likely to be present in insufficient amounts. Iron, sulphur, magnesium and manganese are also essential for green plants. Recent experimental work on the necessity for zinc, boron, molybdenum and copper indicates that other minerals may be necessary in very small quantities.

There is a fairly close correlation between the growth of the below- and above-ground portions of a vegetable plant. The top is dependent on the root system for its supply of water and minerals while the roots must have their carbohydrates from above. If the supply of nitrates is low we may expect to find a root system that is relatively larger than the top, because the carbohydrates cannot be utilized in the tops when nitrogen is deficient. Therefore, more carbohydrates become available for the roots which can make none of their own, but are entirely dependent on the leaves. When there is plenty of nitrogen available the top will be relatively larger because then more of the carbohydrates will be utilized in foliage and stem growth. Although a low content of soil moisture will increase the root-top ratio in the same manner as a low nitrogen supply, actually the extent of the root system is decreased compared to that resulting when the supply of these is adequate.

Any diminution of the nitrogen supply entering the roots will result in a reduction in the quality of top of salad vegetables. Even in a leafy vegetable an oversupply of nitrogen will result in a very tender succulent growth which wilts quickly when cut. Thus it is evident that there must be a balance between soil nutrient supply, especially nitrogen, and the manufacture of sugar by the leaves.

Oxygen.—The living cells of a plant are normal respiring units, whether they be in the roots or tops. Between cells are minute pores or crevices called intercellular spaces through which the oxygen and carbon dioxide movement may take place. Gases may move also in solution. The process of breaking down organic compounds to carbon dioxide and water, by which cells obtain their energy is called *respiration*. Some of these changes take place without the use of additional oxygen and are termed *anaërobic* instead of *aërobic*.

The above-ground part of the plant takes in oxygen from the atmosphere while the respiring cells of the root system must receive their oxygen from the soil air. When the soil is saturated with water, air is driven out of the pore spaces in the soil and the roots are, in effect drowned unless the water is well charged with oxygen.

Soil Reaction.—Excessive acidity or alkalinity of the soil has an important bearing on plant growth. Most vegetables make their best growth on soils that are slightly alkaline to slightly acid. Some are more tolerant of acidity or alkalinity than are others. Efforts

may be made to adjust the reaction of the soil as a means of preventing the growth of some specific disease organism like that causing the club-root of crucifers, or the potato scab organism, or to render certain toxic substances ineffective. When this occurs there is danger of bringing the reaction to a point where manganese or iron is rendered unavailable. A chlorotic condition results and, with chlorophyll deficient, growth is poor.

Salt Concentration.—In some parts of the country soils may have such a high concentration of chlorides, sulphates and carbonates, especially when these are combined with sodium, that injury to vegetables results. Much of this effect may be due to the inability of the seeds or roots to absorb sufficient moisture from the concentrated soil solution. Crops differ in their sensitivity to salt concentration. Reclamation procedures are required to reduce this accumulation of salts.

Diseases and Insects.—The presence of disease is an important agent in the reduction of plant growth. Foliage diseases reduce the efficiency of the manufacturing mechanism. Root or stem diseases interfere with the absorption of water and minerals as well as the movement of these and the elaborated foods within the plant. Insects which destroy part of the foliage or invade the stems will interfere with plant processes.

Plant Growth Regulators.—Most of the growth functions of the plant, such as cell differentiation, leading to the development of roots, stems, leaves, flower buds and fruits are thought to be controlled by growth substances that the plant produces in very minute quantities. Some of these stimulate while others inhibit growth activities. They may be translocated from the part of the plant where they are formed to another part where they exert their effort.

Many organic materials have been prepared synthetically which when applied to plants will serve as growth regulators. The setting of tomato fruits without pollination and the prevention of sprouting of potatoes in storage are examples of the practical use of certain of these.

Summary.—It is apparent that the fundamental influences operating to produce what is termed growth are rather closely interrelated. In the complicated mechanism of growth the processes of photosynthesis, respiration, digestion, transport of materials, and water absorption are so mutually interdependent that if one is upset the rest are affected.

Thus, although some of the factors may be concerned with one specific process, modification of this reacts on others. Understanding the method by which plant tissue carries on, one is able to appreciate more fully the need of an optimum condition of these factors in order to realize the greatest return from the time and money put into the production of a crop.

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Chapter 4

PLANT-GROWING EQUIPMENT

To place entire dependence on Nature for proper growing conditions is to reduce considerably the kinds of vegetables that may be grown, as well as the period during which they may be available. Commercially, the necessity for being ready to harvest for the early market, or even to get a good yield where the season of satisfactory temperatures is short, requires that the grower get his plants or crop started early. The function of the home or farm garden is to provide a continuous supply of a variety of vegetables from early spring until late fall. In the consummation of this ideal it is as desirable that the small gardener have forcing equipment at his disposal, as it is necessary for the more specialized market grower.

Plant-growing structures may be of many kinds, depending on their method of construction and operation, but they fall more or less definitely into the grouping—coldframes, hotbeds, glasshouses, and plant protectors.

COLDFRAMES.

The coldframe might be called the ancestor of our present-day greenhouse ranges which often enclose an acre or more of land under one roof. It is a means of trapping the sun's rays to furnish the plants with a warmer environment, which is conserved to some extent at night by covering the glass with burlap, loose hay, or straw mats. Waterproof mats and straw mats may be purchased. Burlap covering may be made by sewing together old, clean burlap bags and treating them with raw linseed oil and an antimildew preparation.

The absorption by the soil of the heat from the sun ceases an hour or so before sunset so that covering coldframes and hotbeds in late afternoon will prevent radiation of the stored heat to the sky.

In the South and West frames with cloth covers are widely used in starting early plants, since little protection is needed.

Near Norfolk, Virginia, and in parts of New Jersey and Southern New York, considerable acreages of celery are grown to maturity in cold frames. The plants are protected with sash until they are nearly grown.

Coldframes may be used for maturing an early crop of beets, radishes or lettuce, but serve generally for *hardening* plants pro-

duced in the hotbed or greenhouse. They may be used also for wintering over fall-seeded cool season crops.

Coldframes and hotbeds should be located where they can be cared for most conveniently. This involves nearness to an adequate water supply. They may be furnished protection from the winds blowing from the north and west by sheltering them on the south or southeastern side of buildings, fences, trees, hedges or hill slopes.

Frames may be temporary or permanent. When temporary frames have served their function they may be stored or stacked for the summer. The land they occupied may then be cultivated and weeds kept under control. The land may be plowed, fertilized and fitted before the frames are put in place in the fall. Handling

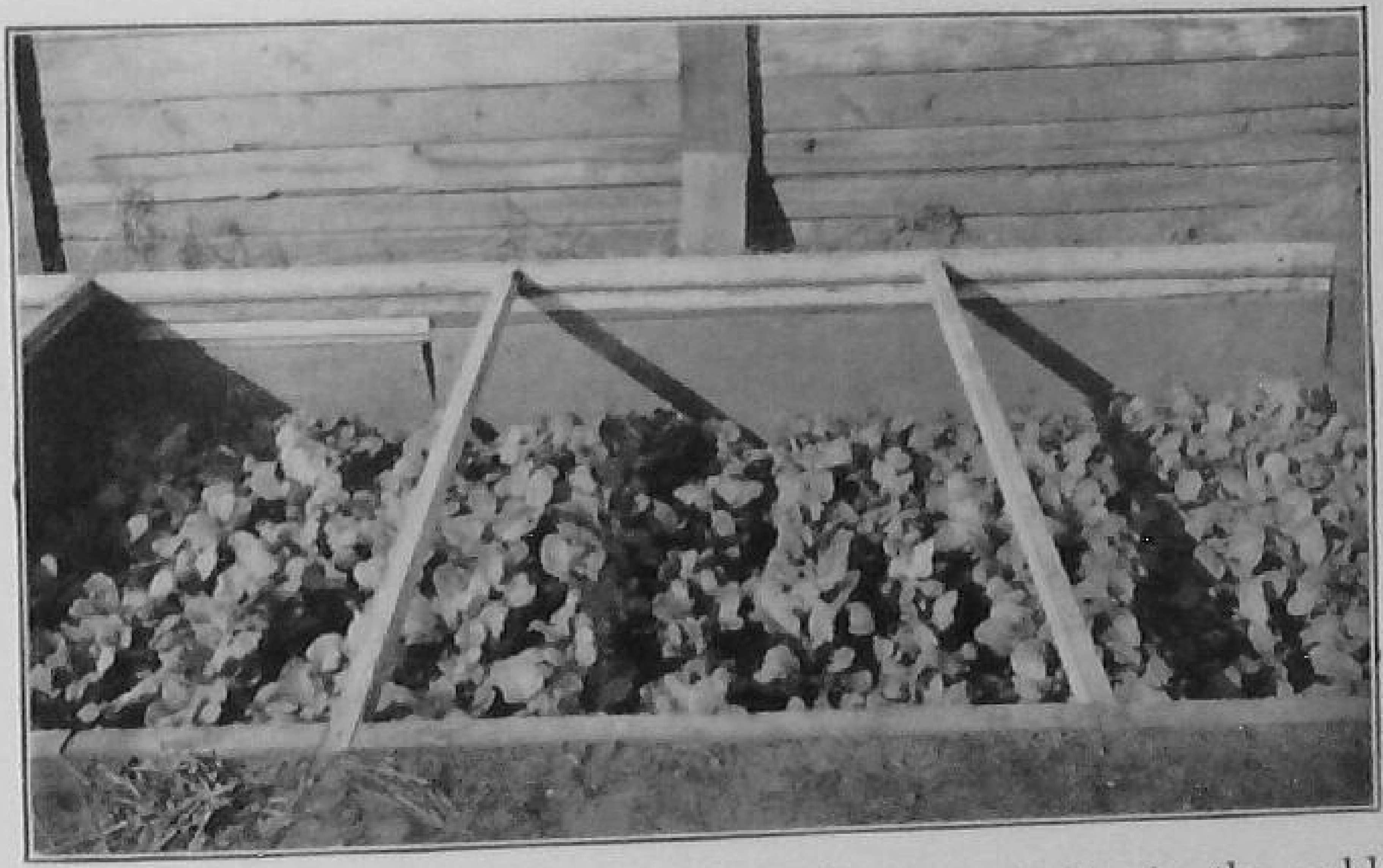

FIG. 6.—A number of crops may be brought to maturity in the coldframe. These radishes are about ready for harvest. (Boyle.)

the frame area in this way permits rotation. Temporary frames are usually constructed of wood, various methods being employed to permit of easy handling. Permanent frames may be of wood or concrete.

Sash.—The standard size of sash is 3 feet wide and 6 feet long, with a thickness of 1⅜, 1⅝ or 1⅞ inches. Frames are spoken of in terms of sash. A 10-sash frame would be 6 by 30 feet.

The wood should be cypress, redwood or cedar in order to give long service. All joints should be of blind mortise type. The tenon ought not extend through the side walls as this would increase the chance of decay.

The sash is made with 2 lengthwise sash bars providing for 3 rows of 6 panes of 10 by 12 inch glass. The wood should be painted with white lead and raw linseed oil before glazing to aid in preventing future decay and the rapid drying out of the putty. The

glass is pressed firmly to the putty, beginning at the bottom of the frame which has a run-off space. This is preferable to putty above the glass since it will facilitate the removal of individual panes in case one is broken. The panes are overlapped about ⅛ inch. Too much lap cuts down the light, while laying the glass end to end—*i. e.*, butting—often permits water to leak in and heat to escape. Special glazing tacks or shoe nails hold the lapped ends together. After glazing the sash should receive another coat of paint.

Double strength glass is used in place of single strength. B quality will prove satisfactory. Poorer quality glass will have air bubbles which act as lenses focusing the sun's rays on the plants, thereby causing burning. A well-constructed cypress sash if properly painted and cared for should last twelve to fifteen years.

Some substitutes for glass do transmit more of the ultra-violet light than does glass. This is not a critical consideration in plant growing. Since the substitutes transmit less total light, become brittle and cloudy with use, glass is to be preferred.

When not in use sash should be carefully stacked and fastened down by nailing laths across the ends. As winter approaches it is well to get them under cover if not already there, as one of the most important mid-winter jobs of the plant grower is to replace broken lights of glass and paint the sash. The glass should be cleaned periodically while in use on the beds so as to allow the maximum entrance of light and solar heat.

Cloth Covers.—Medium or heavyweight unbleached muslin will provide adequate protection where severely low temperatures are not encountered. The cloth can be waterproofed if desired by applying a mixture of 2 to 3 pounds of melted paraffin, ½ pound of beeswax and a gallon of benzene, or by use of commercially available waterproofing materials. Care in drying and storing the muslin cover as soon as it is no longer needed on the bed will prolong its life.

The muslin cover can be fastened to the high side of a single bed or to the ridge pole of a double slope one. It is then easily rolled out of the way. As the cloth will not transmit as much light as does glass the cover should be removed whenever conditions will permit. Thus more heat can be absorbed by the soil from the sun. Its loss during the night is delayed after the cover is replaced.

Construction of Frames.—The simplest type of coldframe would be made for one sash. The back board should be 12 to 18 inches high and the front board 6 to 8 inches less. This pitch will cause fewer of the sun's rays to be deflected from the glass than would occur were front and back more nearly of the same height. These planks should be at least 1 inch in thickness and of some material which is durable and resistant to decay. Oak, cypress, hemlock, cedar and chestnut are frequently used.

Corner posts should be of 2- by 4-inch wood. These should be placed on the outside of the frame. If placed inside they will interfere with the flats fitting into the corners and valuable space will be lost. The ends are cut to conform to the slope of the sash when laid on the front and back boards. The completed frame will have outside measurements of 3 feet by about 5 feet 10½ inches. The bed cannot be 6 feet wide because of the inclination of the sash. Some growers use angle irons and bolts for fastening the corners. These make it easier to handle multisash frames and furnish sufficient rigidity.

Coldframes may be of any length, depending on the number of sash desired, the evenness of the ground and the space available. Sometimes a slot is cut every 3 feet in the top edge of the side

FIG. 7.—Temporary coldframes with the ends removed for efficient preparation of the soil.

boards for insertion of the cross-ties, which may be either plain or grooved with a 1-inch rabbet down the center. These help in sliding the sash off for ventilation. If cloth covers are used light crossbars or rafters are a necessity.

Many of the frame yards of northern New Jersey contain wooden coldframes in which the low side of one frame is bolted to the high side of the next. The 18-inch space between is filled with cinders and may have an irrigation pipe lain along the top. The end boards can be removed, permitting plowing and fitting with a one-horse plow and harrow. A further improvement is to build these with a few cross braces into unit sections which may be moved to a new location and fitted end to end until the proper length is reached. All such adaptations contribute in reducing hand labor in the preparation of the soil, and help in disease control by simplifying rotation of the frame yard. Lines of single sash coldframes such as

have been described are usually run in an east and west direction, with the low side to the south, to take full advantage of the sun's rays. Enough space between frames for sliding off the sash reduces the labor in ventilating. If ample land is available it is well to have a driveway between every other frame. This will save labor and time in handling flats, planting and harvesting.

Double sash frames consist of two frames built back to back. The back boards are omitted and a ridge pole supported by 2 by 4 posts substituted. The sash slopes away from the center. This type is cheaper to construct per unit of land covered and concentrates operations. It is more satisfactory for covering with a long sheet of unbleached muslin than for the use of sash. Arched bows every 4 to 6 feet tied together at the top lengthwise of the bed can be used in place of a ridgepole to hold the cloth taut. Double frames are run north and south to take better advantage of the sunlight.

HOTBEDS.

A hotbed differs from a coldframe in that heat is provided other than that available from the sun. This may be by the fermentation of horse manure, by hot-water or steam pipes, by hot-air flues or by electricity. The heated bed may be used to start plants much earlier than would be possible in the coldframe, and for that reason is almost indispensable to the market gardener unless he has a small greenhouse. Hotbeds may also be used for maturing early crops of quick-growing vegetables in the same manner as coldframes.

A *manure-heated* bed is the cheapest method whenever a plentiful supply of fresh strawy manure is available. Chopped corn stalks, straw, or cotton hulls can be used instead of manure. With these materials some form of nitrogen or a complete fertilizer should be mixed thoroughly with the organic matter at a rate of about 1 to 50 pounds of dry matter. The addition of a small quantity of manure that is in the process of heating is helpful in inoculating the pile. The fermentation process responsible for the evolution of heat is a combustion or burning up of the organic matter by the bacteria feeding on it and the nitrogen. Oxygen and moisture are essential.

A pit should be dug somewhat wider than the wooden frame of the bed. This work must be done in the fall in areas where the ground freezes. The manure, preferably after heating commences, is packed into the pit almost to ground level. A layer of 4 to 6 inches of well-prepared soil is placed over the manure. The frame is then put in place and well banked with soil around the outside to shed water and conserve the heat. The sashes are then placed on the top of the frame.

It is possible to make the pile entirely above ground instead of in a pit. This takes much more manure because the pile has to be

several feet wider than the frame. Moreover the utilization of the heat from the manure is less efficient than with a pit since considerable escapes from the sides of the pile. A general rule is to allow 12 to 15 inches of packed manure if an outside temperature as low as 12° F. may be expected while the bed is to be in use. An additional inch of manure is added for every degree anticipated below 12° F. These quantities assume that the sash will be covered with mats at night. A cord of manure (128 cubic feet) will fill a 6-sash pit to a depth of about 12 inches.

FIG. 8.—The electrical soil-heating cable is arranged before the top layer of soil is added to the hotbed. (Courtesy U. S. Department of Agriculture.)

Soon after fermentation gets well under way the temperature of the soil may rise to 130° F. or above. One must wait until it drops to about 80° F. before seeds are sown or young seedlings transplanted in the bed. Every hotbed user should have a soil thermometer to be certain of the temperature conditions of his bed.

Hot water or *steam* may be used for heating the hotbed. For the home garden a pipe can be run quite handily from the dwelling heating system. Much better control of the temperature is possible than with manure.

In constructing a hotbed specifically for this type of heating no pit is necessary. This saving helps offset part of the cost of the piping. Soil thermometers are necessary to control properly the soil temperature. The double-sash frame described in the discussion

of coldframes is well adapted to hot-water or steam heating. The flow line is located under the center ridge pole and the returns on the sides. With the larger volume of air enclosed in this type better control of the air temperature and moisture is possible. There is a preference among growers for placing the hot-water pipes under the ground. When such a system is being laid out great care is necessary in the location of the boiler pit, the proper size of pipe, and the slope of the flow and return pipes.

Beds heated with hot air, known as *flue-heated* beds, are common in some sections where plenty of cordwood is available. They are cheaper to build than hot-water or steam-heated outfits. The flue-heated hotbed requires care in the location of the fire-box where a smoldering coal or wood fire is to furnish the heat. The hot air and smoke pass up through two vitrified pipes. The fumes escape from the tile tubes and circulate in an open space below the board floor upon which the soil rests or go directly to the chimneys. Satisfactory results can be obtained from this type of heating but the bed will tend to dry out a greater extent than if steam or hot water is used.

Growers are turning increasingly to *electricity* as a source of heat for hotbeds. There are many advantages. The beds are ready for use whenever needed. They can be utilized for two successive crops—first for a cool season one and later for a warm season crop—with little additional labor for preparation. The temperatures can be automatically controlled at the desired level. The cost of operation is not great where a low rate of electricity prevails. Power companies serving rural areas are usually able to supply advice and cost data for their local conditions.

Conservation of heat is of great importance when electricity is used. Therefore the beds must be well constructed. Certainly the walls should be well banked with soil or other material to reduce heat loss. It is desirable to put felt or rubber on top of the side and end walls so the sash will fit tightly. Concrete, tile, or brick could be used for the walls of the bed. However 2-inch lumber has the insulating ability of 10 inches or more of these materials and if painted with creosote or some other preservative will last many years. In very cold climates one can use a double-wall type of wood construction enclosing a layer of insulating material in the intervening space.

The soil must be removed from the bottom of the bed to a depth of 5 to 6 inches. Good drainage is important. Therefore it is well on a heavy soil to take out twice that much, and put in 4 or 5 inches of gravel or coarse cinders topped with an inch of sand for insulation and drainage. The special soil-heating cable is laid on this base. It is run back and forth across the bed with gentle bends at the ends. The parallel strands should be 7 to 9 inches apart. The cable

is covered with 5 to 6 inches of well-prepared soil in which the plants are to grow. Sometimes it is desirable to place an inch of sand above the cable and over it spread poultry wire or ¼ inch hardware cloth before the soil is added. This wire reduces the danger of tools cutting the heating cables.

A 60-foot cable of 400-watt capacity on a 110-volt circuit will heat a 6 by 6 foot area in most climates and more than this where temperatures are not severe. Cables 120 feet long, 800-watts, are available for use on 220 volt circuits. They will warm a 6 by 12 foot bed. The price of the cable is about $7 to $10 for a 60-foot length depending on the number purchased and the supplier.

In beds 30 or 60 feet long, 60- or 120-foot cables can be used respectively and run lengthwise of the bed instead of crosswise as described above. The cable is bent at the far end and brought back to the electrical outlet. With 7 to 9 inches between the parallel strands four cables are needed for a bed 6 feet wide.

Plastic covered cable is less expensive than lead covered cable. Somewhat more than a third greater length must be used to produce a wattage equal to that from a lead covered cable. Thus more units have to be put in the bed and the strands of plastic covered cable laid closer together than where the lead type is used. Manufacturer's recommendations should be followed.

A thermostat is necessary to control the current and maintain a uniform temperature. One with a 25-ampere rating will operate up to six cables of either the 60- or 120-foot length when connected in parallel. This will cost from $10 to $15.

The bulb of the thermostat is inserted into the soil at the point where the desired temperature is to be maintained. In order to have the air temperature about the plants within the ranges suggested in Chapter 7 one must set the thermostat to control the soil at a higher temperature.

When electricity is used for heating a hotbed a material saving in power will be realized by covering the sash at night with mats, pads or straw.

GLASSHOUSES.

In inclement weather it is difficult to care properly for the plants in the hotbed or to do planting. This factor coupled with the replacement of manure by other methods of heating has led to the increased use of sashhouses and small greenhouses. By digging an alley down the center of a doublesash hotbed the grower has an elementary form of greenhouse. By raising the height of the ridge pole, better facilities for moving about are provided, the larger volume of air enclosed provides improved plant-growing conditions, and this so-called dug-in house is easier to heat than are more exposed ones.

Above-ground houses may be built against a dwelling as a lean-to. Some means of ventilation must be provided and this factor is often neglected. Most of the greenhouse construction firms have one or more types of small units which may be purchased. Hot-water heating is the most desirable. Sashhouses are often heated by hot air and smoke from a stove or a sunken fire-box. The hot air and smoke go through a pipe or tile in the house before passing out the chimney.

While a small sashhouse will be adequate for the gardener with only a few acres, the large operator may well afford a glasshouse of considerable size. He will usually find an outlet for his surplus

FIG. 9.–A sashhouse heated by natural gas. The rear or first unit was so successful that the grower built an addition the next year. Note the method of ventilating.

plants by sale to home gardeners or smaller market growers. The glassed area can be used at other times of the year for the production of out-of-season crops. Such production–vegetable forcing–employs methods quite different from field culture and is beyond the scope of this book.

MANAGEMENT.

Good equipment is of little avail unless proper care is given to watering, temperature and ventilation. These three factors are closely interrelated and are discussed in Chapter 7. When fresh air is admitted to the frame, bed or sashhouse the plants are supplied with carbon dioxide and oxygen but more important is the effect of carrying off the moist air from around the plants. If properly ventilated no moisture will condense on the under side of the sash.

The plants will require a larger amount of water with adequate ventilation, yet a more desirable type of growth results. Too much ventilation may reduce the air temperature below the proper range. Always lift the sash or ventilator at the side away from the wind. A brick or better still an 8-inch piece of 2 by 4 provides several degrees of ventilation. Some growers prefer a small board cut in steps.

Weeds compete with crop plants for all their necessities, and it is therefore part of good management to see that no weeds are allowed to grow when the frames or beds are not producing crops. Soil disinfection will kill most weed seeds.

Fig. 10—Weeding, thinning and replacing paper caps on early cucumbers.

PLANT PROTECTORS.

The use of some type of protection for the individual plant or hill after it is set or seeded in the field is another means of contributing to early maturity.

The function of these is to give an increased day temperature and furnish protection from light frosts. It is essential that there be some means of ventilation. If moisture condenses on the inner surface and the plants are in contact with this, greater frost injury will often result than if the plants were entirely unprotected.

Glassine, waxed or parchment paper protectors are used on early plantings of warm season crops in both market gardens and in large scale production. Some of these covers are already shaped, often with cane, wire or bamboo splints to help hold their form. Others come in flat sheets and have to be shaped. If the paper is

too light it is crushed by beating rains. Sometimes two hooped wires are stuck in the soil and the paper laid over these. The 16 by 18 or 18 by 20 inch sizes are adapted for covering seeded hills of cucurbits. However, for tomatoes and plants of similar type a 24 by 24 inch size is better, as it makes a tall cone. Soil is pulled over the bottom edge of the cap to hold it in place. The paper is available in rolls for use over a seeded row. It should be supported by wire and anchored in place by covering the edges with soil.

Careful attention must be paid if the grower hopes for success. One cannot put on the caps and forget about them. The soil should contain plenty of moisture before the caps are put in place unless it can be supplied by subbing from an adjacent irrigation furrow.

A slit 1 inch long should be made on the side of the cap away from the prevailing winds soon after the cap is placed over a plant in order to get rid of the excess air moisture. This is lengthened as the plant develops and eventually the cap is pulled apart and the plant stands fully exposed. If used over a seeded hill no slit is necessary until the seedlings are up. Ventilation may be given by folding one edge of the paper upward from the soil to form an entrance to the cone.

When seed is planted under caps, the caps should be lifted off after a few weeks, the plants given a partial thinning, the weeds removed, and the caps replaced. The bottom of the side away from the prevailing wind should be turned up for ventilation. Later when the caps are removed the final thinning is given.

The paper caps should not be removed on bright sunny days in cases where plants have not pushed through the ventilation openings. Since the plants are tender, the sudden exposure to bright sun would be disastrous.

In an emergency for an unexpected late frost peach baskets or large flower pots with the central hole covered by a stone will serve to protect the plants from injury. Plants may also be laid over on the surface of the garden and covered for the night with 1 or 2 inches of soil. When uncovered the next day they will be little the worse for the experience.

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Chapter 5

THE SEED SUPPLY

THE seed is the basis of the crop that eventually is to be harvested. Within the seed coat may be locked up the key to future success or failure. Of two samples of cabbage seed of the same variety, one may be a strain which will produce a large percentage of mature heads at the first cutting when prices are high. The other will cut heavily ten days or two weeks later when cabbage is selling for much less. There may be also as much as a 50 per cent difference in yield. The grower will have spent the same amount on each crop for growing the plants, preparing the land, fertilizing, and in controlling weeds. Yet how different his return. The better strain of seed will possibly cost $6.00 a pound compared to $3.00 for the poorer. Enough good plants for 4 acres can easily be obtained from a pound of seed even after very rigorous culling. Would anyone be justified in refusing to pay 75 cents more an acre in view of the tremendously increased returns? But the price is not always an index of high quality, although we have known people to base their purchases almost wholly on this factor. The reputation of the seedsman, that will assure obtaining the strain desired, rather than the price should be the determining factor as to where one buys his seed.

Seed Production.—The production of seed to supply the needs of the seed trade has become a very specialized industry. It is centralized in localities which are peculiarly adapted because of soil, climate, and often, also, freedom from disease. Lettuce and carrot seed are mostly produced in California, beans and peas in Idaho and eastern Washington, and much of the muskmelon seed in Colorado and California.

The commercial production of seed consists of at least two steps. Stock seed is grown under very careful supervision from the plants most nearly ideal. These seed plants are thoroughly "rogued" by removing all that are weak, diseased or off-type. This first step is usually accomplished on farms owned by the seed specialist or otherwise rather directly under his control. This stock seed is then furnished to growers who contract to produce a certain acreage. The fields are inspected and rogued during their growth. The harvest from these fields goes into trade channels. The greater the care taken to produce this contract seed the higher must be the cost. Similarly, the value of stock seed, if it can be bought, is

necessarily still higher. Some seedhouses have trial grounds where the seed of each individual lot is tested for purity. If a customer objects to the kind of crop which seed he bought of them produced, the seedhouse can turn back to the lot number and find how it grew in the trial grounds. This protection adds to the cost of seed.

It is easy to blame a poor crop to the seed and this is the first thing of which a grower usually thinks. However, seasons vary, or a slight difference in the method of culture may be the factor responsible for the lack of success.

Many of the smaller seedhouses have no trial grounds or facilities for producing much of their seed. They buy from the larger sources, and take what precautions they can to insure the purity of their purchases. A retailer in Florida, one in Missouri and another in Maine may all be selling cabbage seed which grew in the same field in Washington or in Denmark. Most seedsmen realize that confidence on the part of their customers is of inestimable value and can usually be counted on to do their best.

Retail costs may offer the explanation for a difference in price in the case of two seedhouses when their supply may have come from the same wholesale source. An elaborate catalogue, heavy overhead charges, or the listing of a considerable number of the older varieties are all causes of a difference in price. Reduction to a few of the more desirable varieties has been taking place. Many people still call for old types which are now inferior. To get the orders of these customers, seedhouses must be in a position to furnish what is wanted. It is to the advantage of the seller to be closely in touch with superior new developments so he may inform his customers and thus reduce the range of his stock.

The offerings of a seedsman fall into four classes:

1. **Standards.**—These are the older well-known varieties which are demanded by the majority of the customers. Those of inferior merit will in time be replaced as more meritorious varieties become better known. Seedsmen may differ in the strain or stock of the "standards" which they carry.

2. **Specialties.**—A certain seedhouse may specialize in tomato seed, and another celery. While they carry the usual assortment, they will place their special efforts on the purity and excellence of these one or more kinds of vegetable seed. Thus they build up a reputation, and may become the source from which other seedsmen will obtain their supplies.

3. **Certified Seed.**—Some states have agencies for certifying seed of vegetables, notably tomato, cabbage, and onion. Such seed is certified as being free of particular diseases, and in a few states, as being true to variety. The costs of certification are such that one must expect to pay more for certified seed than for that which is uncertified.

4. **Novelties.**—New developments or improved types are constantly appearing. If the originator is not connected with a seed firm he may sell his rights to some firm which then becomes the introducer. Novelties which have been introduced by one seed firm, later may be put forth by others as being worth a trial. There is a tendency in our present-day seed catalogues to stick rather closely to statements of fact in place of the glowing descriptions to be found in older sales talk. Most novelties are rather carefully tested before being introduced. The progressive vegetable gardener will receive these novelties or new introductions with an open mind. While he still makes his main plantings of a stock he knows will do well under his conditions, he wisely tries a small planting of the new. It is essential that this test be made under exactly the same conditions as provided for the main crop.

TABLE 1.—THE APPROXIMATE AGE AT WHICH SEED OF GOOD INITIAL GERMINATING POWER STORED UNDER PROPER CONDITIONS WILL STILL GIVE SATISFACTORY GERMINATION.

	Years.		Years.		Years.
Asparagus	3	Cress, garden	5	Parsnip	1
Bean	3	Cress, water	5	Pea	3
Beet	4	Cucumber	5	Pepper	4
Broccoli	5	Dandelion	2	Pumpkin	4
Brussels sprouts	5	Eggplant	5	Radish	5
Cabbage	5	Endive	5	Rutabaga	5
Cardoon	5	Fennel	4	Salsify	2
Carrot	3	Kale	5	Scorzonera	2
Cauliflower	5	Kohlrabi	5	Sea kale	1
Celeriac	5	Leek	1	Sorrel	4
Celery	5	Lettuce	5	Spinach	5
Chervil	3	Martynia	1	Squash	5
Chicory	5	Muskmelon	5	Sweet corn	1
Chinese cabbage	5	Mustard	4	Tomato	4
Ciboule	1	Okra	2	Turnip	5
Collard	5	Onion	1	Watermelon	5
Corn salad	5	Parsley	2		

Characteristics of Good Seed.—*Good Seed Should be Viable.*—Kinds of seed vary in the number of years during which they will give satisfactory germination. Besides this, the vitality of a given lot of seed depends upon the initial germinating power as influenced by proper maturity and curing to low-moisture content, freedom from disease and insect injury, and storage in a dry, preferably cold place. Figures for the longevity of vegetable seeds, compiled from various sources, are given in Table 1. Satisfactory germination is assumed to be such as to provide an adequate stand of vigorous seedlings with a normal rate of seeding.

A few crops such as parsnip and onion, as indicated in Table 1, lose viability rapidly. Even these may be kept longer if special care is used. The moisture content of seed rises with the humidity of the storage place. When high humidity is combined with high temperature as in the southeastern states the life processes of the seed are stimulated. Loss of vitality is rapid.

Seeds that are to be stored must be reduced in moisture content as much as possible by drying in a shallow layer in the sun or in a normally heated room. They should then be sealed in a container and placed in as cold a situation as is available. If the moisture content is not low the seed may deteriorate faster in an airtight container than in a bag in a room with a low humidity.

Large lots of seed should be put through artificial drying chambers. A temperature of 120° F. is safe but the period of drying depends on the kind of seed and its initial moisture content.

Table 2.—Variation in Vitality of Radish Seed from Different Sources as Shown by Soil and Rag-doll Tests.

Variety	Per cent germinating. In soil.	Per cent germinating. In rag doll.
Crimson Ball	96	100
Early Scarlet Globe	72	97
Red Rocket	25	79
Scarlet Globe	33	59
Earliest Scarlet	25	63

Many seedhouses now stamp the packets and sacks of seed with the percentage germination and date of the last test. When seed is carried over from year to year, or is home grown, a test just before planting time is well-expended effort.

A vitality test may be either of two sorts, in soil (germination test) or in an artificial germinator (sprout test). A soil test really gives more valuable information since many seeds will have vigor enough to put forth a little sprout but would be unable to push up through a layer of soil. Either 25, 50 or 100 seeds are planted at the proper depth for their size, and the number appearing above ground after a sufficient time indicates the percentage germination. A cigar box of soil back of the stove or in some place where the temperature is about 70° F. makes a handy home tester. The soil must be kept moist but not soaked. Covering with a sheet of glass aids in maintaining a uniform soil moisture content.

The fact that many samples of seed have vitality enough to sprout but not grow is shown by Table 2, taken from some work by M. T. Lewis, of the Pennsylvania Experiment Station.

The simplest test for viability is to place a counted number of seeds between moist blotting paper or paper towel in a dish. A

dish inverted on top prevents excessive drying. This should be kept in a warm place. This set-up has its more elaborate counterpart in the germinating chambers used by seed analysts. A very great number of samples may be tested in these at the same time under conditions where the temperature and humidity are carefully controlled. A ragdoll seed tester is advantageous when any considerable number of samples of large-sized seed such as peas, beans or corn is to be germinated. This is a strip of flannel or muslin 16 inches wide and 3 to 5 feet long, marked down the center and with cross-marks every 4 inches. The sections are numbered. When the seed is in place the edges are folded in and the whole rolled rather tightly about a cob or cylinder of ¼-inch mesh wire. It is fastened at both ends with cord or elastic.

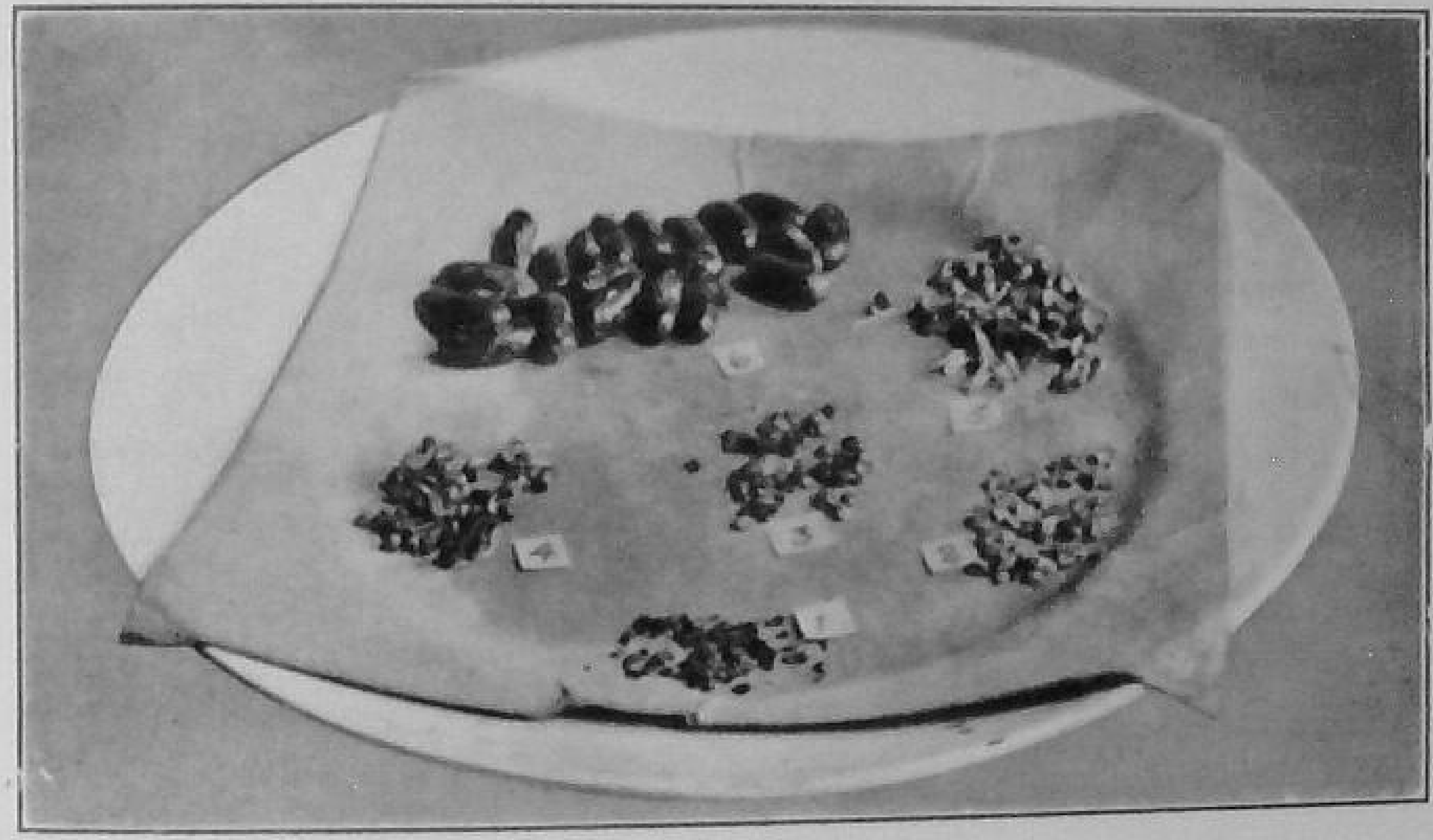

Fig. 11.—The blotter test of last year's seed kept moist between dishes is a handy method of determining the percentage of viability. (Boyle.)

The completed roll is soaked for two to four hours in luke-warm water, drained, placed in a bucket or crock, and kept covered with a moist cloth. When the sprouted seeds are counted and removed from the artificial germinator note should be made of any which are apparently weak, as these would probably be unable to produce thrifty plants.

Good Seed Should Not Contain Weed Seed and Foreign Matter.—Seedhouses are equipped with fanning mills and other types of seed-cleaning machinery adapted for special crops. These remove sticks, chaff and the lighter weak seeds. Peas and beans are often carried along a belt which runs slowly past pickers who remove diseased and immature seed as well as foreign material. These seeds may then be put through a polishing process to improve their appearance.

With proper inspection and removal of weeds while the seed crop is being grown there should be little danger of vegetable seeds containing many weed seeds.

Good Seed Should be Free from Disease or Insect Injury.—Weevil injury in peas and beans is the principal kind manifest in vegetable seeds. This is seldom a cause for complaint in commercial seed.

There is greater danger from disease since the spores of many troublesome diseases are carried on the outside or just within the seed coat. If in doubt as to the freedom from disease the grower may well treat his own seed for the particular diseases likely to be present.

Seed-producing regions have moved into sections where certain diseases are not present, and seed from these sources is most desirable because it has never been infected.

Good Seed Should be True to Name and of a Good Strain.—When the grower buys seed he does so with the expectation that it is the variety which he especially desires. There are cases where a similar variety could be substituted for the one he wished with no resulting harm. But when he plants seed for a round-button radish like Early Scarlet Globe and harvests a slower maturing crop of Long Scarlet Short Top his feelings for the seedhouse will be far from complimentary. In this respect the grower must bank on the character and reputation of the seedhouse from which he buys his supplies. Even though he has the utmost confidence in the integrity of his source of seed, it is well to work out some system of trying the seed a year in advance.

Since most seed can be carried over it is evident that a grower can buy most of his seed a year ahead of its intended use. A sample of this may then be planted along with the main crop and a true picture obtained of the potentialities within the seed. If the plants prove to be undesirable the gardener will be money ahead if he disposes of that seed and buys a new supply. This may or may not be just what he wants, but at least it is better to take the chance than to plant seed which he knows to be undesirable. The grower of celery, lettuce, cabbage or cauliflower can avoid this dilemma by keeping two years ahead.

Varieties differ in certain rather prominent characteristics. Within varieties we have strains which vary in several minor or even one major consideration but not enough to entitle them to variety standing. Careful attention to strains is of tremendous importance to the commercial vegetable grower. The differences between strains may be in earliness, yield, vigor, uniformity, habit of growth, adaptation to certain climatic conditions, or disease resistance. Strains may vary in their performance on different types of soil. A two-year test of 26 strains of Chalk Jewel tomato at

the Pennsylvania Experiment Station showed a range in the average early yield of from 0.37 to 2.20 tons an acre and in the average total yield from 12.01 to 21.05 tons. A strain which gives a good early harvest may or may not give a heavy total yield. Growing a small plot the year before a given lot of seed is used for the main planting will check up on strain adaptations.

Where to Buy.—From our consideration of the requisites of good seed and methods of commercial seed production, it is obvious that the only answer that can be given is to buy from a reliable firm as near the source of supply as possible. By that we mean purchase from the specialist instead of the dealer who may have

Fig. 12.—The commission box of seeds at the neighborhood store is not always a reliable source of seed. (Boyle.)

filled his stocks with little attention to origin. Superior seed is worth a higher price, and the seed cost is but a small part of the costs of growing a crop. A study of the firm will indicate whether the greater price asked represents more careful production or just sales overhead.

When fair-sized orders are given it is often possible to obtain the stock number. Thus one may be able to order seed of the same parentage the next year. This may not help if the integrity of the seedhouse is such that they might make a substitution, or if seed of that particular stock may be short for some unexpected reasons. While stock number purchases are worth attempting, the wise grower will use also the method of testing seed a year in advance.

Many local dealers have studied the seed business carefully and carry the best stocks of seed. They are in touch with your conditions and know your needs. It is not hard to judge whether their seed sales are merely a sideline or whether thought and care are given to the proposition. If you have faith in their judgment, get your seed locally.

It might be thought necessary to shop around among the members of the seed trade, getting celery from one, cabbage from another and so on. In many respects this is advantageous if you have found that some particular seedhouse has the stock you wish. Since many go to the same wholesale source for their supply it may be that the man who carries the celery you like has the same stock of cabbage that you have been getting from someone else.

What about the home gardener and the grower who needs but a small supply? He wants seed that will come up, be productive and be free from disease. Can he get this from the display boxes in the drug store, grocery or five-and-ten cent store? These commission boxes are supplied by all types of firms—from the reliable to the unreliable.

Some states have seed-inspection laws under which seed packets are obtained in the open market, tested, and the results published for the guidance of the buying public. Their results indicate that those long-established seedhouses who put out such packets make every effort to place in them seeds of good quality. At the end of the season the unsold packets may be collected, dumped together, and enough fresh seed added to give a satisfactory germination, or all unsold packets destroyed.

Tests for trueness to variety in field plantings made from packet seed have sometimes shown a wide variation, but here again those from the better known seed firms were best. While the commission-box method of buying the seed supply is quick and easy, it is much better to obtain the catalogue of some long-established, well-known seedhouse and order the small-size packets which are listed.

Home Production of Seed.—One frequently hears of the seed of some vegetable which has been selected from year to year or even handed down from generation to generation. Some such eventually appear on the market as novelties, or new varieties.

Many market growers have learned the technique of selection methods and by extreme care have gradually developed strains which are in great demand by the seedsmen. Thus these gardeners produce enough for their own supply and find a profitable outlet for their surplus.

There is a thrill in the idea of producing a superior strain or variety but relatively few of us have enough skill, patience and abiding enthusiasm to persevere in bringing the new into being.

In the early days of the American colonies before many seed-houses were in existence most of the supply of seed for the home gardens in this country was saved of necessity from the best plants in the garden itself. Now with increased prevalence of disease, market demands for particular characteristics and the lack of time available to most market growers, home saving of seed has nearly ceased to be an important source of supply.

In general the home production of seed is of questionable profit. It takes expert knowledge to select properly the best plants for seed production, to harvest at the right stage of maturity and to cure the seed in such a way as to insure good germination. Moreover, in the case of biennial vegetables, as celery, cabbage, carrot, beet and the like, the gardener may have considerable trouble in storing the roots or plants over winter. The setting of these seed plants in the spring conflicts with his usual operations. The beginner should try, therefore, the annuals or crops which will mature seed the first year.

Another disadvantage is the danger of crossing between varieties of the many kinds which are open pollinated. With tomatoes, peas, beans and lettuce, this disadvantage does not exist to any appreciable extent since they are usually self-pollinated. Not only will varieties of members of the mustard family as listed in the botanical classification in Chapter 2 intercross but there is danger also of crossing between the closely related species. The cucurbit group, on the other hand, does not cross readily between species.

In favor of home saving of seed where a considerable isolated area of a given variety is grown may be credited the fact that somewhat better care is probably possible in selection than is true in the growing of contract seed. Further than this the undoubted value of climatic and soil adaptation of the selected plants is important.

Those persons who desire to try their hand at home saving of seed are referred to the excellent publications on this topic. It is hoped that they will remember that the plant is the unit, and that a large smooth tomato, picked from a plant of low production or one having many rough fruits, is not as desirable as a somewhat smaller one on a very productive plant. Similarly fruit produced at any time in the growing season is just as good for seed saving as the first fruit ripening on that particular plant as long as the plant was one which furnished a large number of early fruits.

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Chapter 6

SEEDAGE

THERE are three external requisites for the germination of any seed—temperature, moisture and oxygen. Although the seed may take up water and be exposed to the proper degree of temperature, yet if the oxygen supply be low or the carbon dioxide increased above the normal amount the little seedling will scarcely appear. In the operations of soil preparation and seed sowing, these essentials always must be kept in mind if the optimum stand of seedlings is to be obtained in every flat that is seeded.

Soil Preparation.—The first steps in the preparation of the soil which is to be used in flats or hotbeds for starting seed should be taken at least a year in advance. Every gardener should have a compost heap since it will give him a valuable outlet for all relatively disease-free plant material which would ordinarily be thrown away. Hay, straw, lawn clippings, tops of root vegetables, leaves and trimmings of various crops, all may be placed in the heap, rotted down and later incorporated in soil for plant growing.

Although thick heavy clover or grass sods are ideal, they are not always available. A layer of sandy loam soil or stacked up sods about 12 inches thick is spread out to cover the area of the contemplated pile, 6 to 8 feet wide and any desired length. The relative thickness of the succeeding alternating layers of manure and absorbent material is dependent on the kind of soil and its present organic content. Muck, peat or leaf mold may be used in place of part of the soil. The waste plant materials mentioned above can be worked into a pile. Soil should cover the whole in order to confine the ammonia gases arising from the manure. The heap is usually carried to a height of 4 or 5 feet.

The object of the compost heap is to obtain as intimate a mixture of the manure and soil as possible. It is well to cut the pile down with a spade and turn it over after decomposition is well under way. This mixing should be repeated several times before the compost is used. Soil-shredding machines do a good job.

When it is apparent that the compost pile will have to be used in a shorter time than six months, mixing soil with manure of small straw content will produce a fair combination. Neither can the mixing of soil and rotted manure just before use be expected to give as good results as composting.

Since many seeds must be started while the ground outside is frozen, some method must be employed to provide enough soil for these early seedings. It may be stored in barrels or boxes in the cellar and in bins under the benches in the greenhouse. Where extra space in a hot-water or steam-heated frame is at hand this may be filled with soil. Sash may be put in place and heat turned in to thaw out this soil when it is needed. Probably nothing is a greater hindrance to the gardener who is trying to grow plants for the first high-priced markets than the inability to obtain the soil he needs in early spring.

In the final preparation of soil for seeding and plant growing it is often desirable to have at hand a supply of well-rotted manure. This may be made by stacking the manure in a straight-sided pile as in the preparation of fresh manure for the hotbed, but allowing fermentation to proceed and ultimate decay to take place.

Well-rotted manure is an advantage in that the weed seeds have been largely destroyed; it is short and fine, thus working into the soil easily. It takes approximately 2 tons of fresh manure to produce 1 well-rotted ton.

A good soil for seed sowing must be of such texture and structure that it is friable when dry and will not form a crust over the seeds, since this would check the emergence of the seedlings. It must have a sufficient content of well-decomposed organic matter to hold moisture against too rapid drying. Alternate periods of dryness and wetness are not conducive to good germination. The soil must be fine enough to fit compactly around the seeds, that they may take up moisture, yet must provide good aëration. It need not be necessarily a rich soil since the seedlings may remain but a week or two before being transplanted to a wider spacing. The seedlings in a rich soil may develop too rapidly to be handled by a limited supply of labor. A less fertile soil for seeding will result also in a proportionately greater root than top growth which may be an advantage in the approaching shift.

The organic matter incorporated during composting and the well-rotted manure serve to increase the water-holding capacity of the soil as well as to make it light and friable. Sand also may be used to lighten the soil and aid in aëration.

The proportion of the ingredients depends on the kind of loam at hand and the method of composting. The materials should be screened together through ½-inch mesh wire to remove the coarse lumps. Mixing 2 or 3 parts of heavy loam, 1 part of rotted manure, muck or leaf mold, and 1 of sand will make a good soil. If the loam is lighter with a fair organic content then 3 or 4 parts may be used to the 1 each of manure and sand. Many plant growers prefer to mix 2 parts of manure instead of 1 in the above combination. The pile after screening should be shoveled over several times, mean-

while adding water through a sprinkling nozzle until the soil is of such a degree of wetness that it will pack when squeezed in the hand, yet crumble readily when touched. It is best to allow the pile of prepared soil to stand overnight before use as the water has an opportunity to become more thoroughly distributed on the surface of the soil particles. Disinfection of seedbed soil is discussed in Chapter 13.

Seedlings can be grown to the pricking-out stage or even to field transplanting size in sand. The sand should be partially sterilized with boiling water or formaldehyde. In the latter case the sand should be washed out with hot water a day or two after the formaldehyde solution was applied. Sand culture reduces losses from seedling diseases. Fertilizer must be used in sand culture.

It is desirable to fertilize the seedlings about once a week by sprinkling on a solution in which 6 level teaspoonsful of a commercial fertilizer such as 5-10-10 analysis have been stirred in a gallon of water to dissolve the soluble part. It is possible to use other materials such as a teaspoonful each of potassium nitrate (saltpeter), superphosphate, and magnesium sulphate (Epsom salts) in a gallon of water. A light sprinkling with plain water will rinse the foliage. On a large scale fertilization is done with a hose.

Sphagnum moss can be used in place of sand by following a similar practice of fertilization. The cost of the moss is more than that of the sand.

Use of Flats.—Shallow boxes 2 to 3 inches in depth and of such a size that they will fit conveniently into a coldframe are known as flats. The outside dimensions are about 11½ by 16 inches or 16 by 23 inches. A 2-inch depth is enough for most crops. The larger flat in a 3-inch depth is rather heavy to handle. One can fit 12 of the small or 6 of the larger size flats under each sash of the frame with just enough room to spare for grasping them when the time comes for taking the plants to the field. The ends should be made of ⅝-inch wood, but ¼-inch thickness will serve for sides and bottoms. Cracks ¼ to ⅜ inch wide are left between the bottom boards for drainage and swelling. Durable wood such as pecky cypress, redwood or chestnut is preferable, but scrap-box lumber will do.

Some growers prefer a bottom made of ⅛- or ¼-inch mesh galvanized wire. The flats last longer. The soil in a screen-bottom flat dries out less rapidly as it makes a closer contact with the soil of the bed or frame. Since the roots emerge from the wire more easily than through cracks in a wood bottom, there may be less tendency to become root-bound. However, the screen on a large-size flat will sag when the flat is lifted, which may break the soil block and injure some of the roots close to the stems.

The advantage in the use of flats lies in the fact that it is easy to shift the plants from place to place in the greenhouse or hot-bed, then to the coldframe and ultimately to the field. There is less back-breaking labor when seed is sown or seedlings transplanted into flats at a bench or table than when one must lean over the edge of a frame. Flats may be placed on shelves or other unoccupied places in the sashhouse, or in a sunny window of a kitchen, thus utilizing space otherwise vacant. Since the flat may be carried right to the field the plants are not as severely checked through drying out of the roots as is the case when they must be dug out of the seedbed.

Filling the Flat.—A thin layer of the coarse soil particles and manure remaining from the sifting process is placed in the bottom. The flat is then filled to within ½ inch of the top. With the fingers or a small block of wood the soil is firmed carefully at the sides, ends and corners. This prevents excessive drying out, or a cave-in when later the flat is watered. Little firming is necessary in the center. Enough fine soil is then sifted on through wire of ¼ inch or less mesh to fill the flat. This gives an excellent soil condition right about the seeds. A piece of lath makes a handy tool for leveling it off crosswise the width and marking furrows, if its length is slightly less than the inside length of the flat.

Soaking Seed.—It is the practice of some to soak seed in water before sowing. This brings water into more direct contact with the seed coat than may be the case in soil. Some believe that soaking imparts a stimulation to the seed which will cause it to yield larger crops. If seedlings from dry seed and soaked seed appear above ground at the same time there will be probably little difference in growth. Instead of hastening germination the soaking may actually delay it a few hours depending on the conditions of soaking. If seed is to be soaked, this should be done in a shallow pan, where the seed is in a thin layer barely covered with water. Otherwise the intake of oxygen and exit of carbon dioxide may be affected as the seed takes up moisture and the rate of respiration increases.

Soaking may be helpful in starting the germination process possibly twenty-four hours before the seedbed will be ready for seeding. Thus a day may be gained. If soaked seed is dried slightly so as to go through the seed drill, it will take up soil moisture more quickly than would unsoaked seed.

A modification of this practice is followed by many celery growers, and can be adapted to carrot, parsley and parsnip. These all require ten days or so to germinate and then send out rather weak sprouts which may result in a poor stand if the soil becomes packed or crusted from hard rains or drying. The seed may be spread out on a strip of cloth which is handled the same as a rag-doll

seed tester. Under these conditions a good percentage sprout will be obtained. As soon as the white tips of the sprouts begin to show, the seeds may be shaken from the cloth, dried slightly by mixing with very fine wood ashes, dust or meal, and seeded at once. They will pass through a seed drill with little injury if taken at the proper stage of development. The seeds need but a very shallow covering of soil, especially if they can be watered after planting. In fact many who grow celery on muck soil just distribute the sprouted seed on the surface and firm it slightly. The weather may become a hindering factor if it interferes with seedbed preparation or seeding when the sprouting has reached the desired stage.

FIG. 13.—Sowing tomato seed in a flat. The seeds are shaken from the envelope and distributed evenly in the broad furrow.

Sowing Seed Under Glass.—The time of sowing in the spring depends on the crop, the date at which field setting is possible, and whether the plants are to be transplanted into a wider spacing or taken from the seeded row to the garden. Too often the tendency is to start the plants too soon. It is far better to have them make a continuous growth with a short period of hardening before being set outdoors, than it is to have them develop to such size that a serious check is necessary before time for setting in the field. A growth period under glass of three to four weeks is long enough for beets, Chinese cabbage and the cucurbits, while ten to twelve weeks is not too long for onions or eggplant. From six to eight

weeks is about right for most crops. Later in the season it takes a shorter length of time to produce the same amount of growth.

Late cabbage need be started only five or six weeks ahead of field planting.

Seeding in rows in the flat instead of broadcasting provides greater ease in removing the seedlings at transplanting time. By facilitating circulation of air about the stems and drying of the surface the rapid development of "damping off" fungi may be retarded. Seed treatment to control "damping off" is discussed in Chapter 13. Watering may be done between the rows without wetting the plants. The cracking of the soil over a row of seeds by the upward pressure permits some of the weaker ones to develop which probably otherwise would fail to appear. By the broadcast method the seed may be planted more quickly and the seedlings are less crowded.

The furrows may be made with the narrow side of a piece of lath, the depth depending on the size of seed. A general rule for planting under the rather ideal conditions which can be provided is that seed to be covered to a depth of about four times its diameter. Very fine seed should be covered lightly if at all. A flat-bottom furrow is better than one that is V-shaped as the seeds are not so crowded. To this end the lath may be pushed down twice for each furrow, making the little ditch about ½ inch across. If the soil is too dry the furrows will not hold their shape, and if it has been packed too hard it is difficult to press in the straight edge.

Rows of seed should be about 1½ to 2 inches apart according to the erect or spreading nature of the future seedlings, and the length of time they will remain in the flat. In the hotbed or cold-frame 4 to 6 inches is none too much for cabbage and similar crops which will not be moved until planted in the garden.

An envelope sealed and clipped off, or even the seed packet itself, if a clean edge is cut at the end, is convenient for scattering the seed. A rough edge interferes with the free flow of seed. The paper may be tapped lightly with a pencil, or a shaking motion lengthwise the row will serve to secure uniform distribution. This is more rapid than dropping the seed with the fingers. The thickness of the seed in the row varies with the kind of vegetable, and the percentage of vitality shown by the germination test. An eventual stand of about 10 seedlings to the inch is desirable if they are to be transplanted, otherwise somewhat less. From 80 to 90 celery seeds may be placed in an inch of row. Table 3 gives the approximate number of seeds in 1 ounce of some of the crops started under glass and the number of good plants which may be expected. Germination losses and culling of poorer plants in transplanting are responsible for this difference. In outdoor seed-beds the germination may be still less with consequent reduction in the plants expected.

A *covering* is easily provided by turning a little soil over the seed with a small wooden label run along each side of the row. Fine sand is often applied as a cover, by letting it flow out of the hole in a small clay pot. The rate of flow may be adjusted by the forefinger. The surface of the soil is now firmed and leveled with a small block of wood. This brings the soil into close contact with the seed. It should be thoroughly soaked with water through a fine spray nozzle. If soil of proper moisture content has been used it will take up this water far more readily than drier soil with less resultant washing out of the seed. Flats may be stacked up for several days which reduces drying out. If spread out they should be covered with newspaper or a piece of glass which will serve also to raise the temperature in sunshine. A single or double piece of moistened burlap makes an excellent cover for very small seed especially. The top of the burlap will

TABLE 3.—THE APPROXIMATE NUMBER OF SEEDS IN AN OUNCE AND THE GLASS-GROWN PLANTS WHICH MAY BE EXPECTED.

	Seeds in an ounce.	Number of plants.
Cabbage	7,500	2,500 to 5,000
Lettuce	25,000	7,000 to 10,000
Tomato	11,000	2,500 to 4,000
Celery	80,000	10,000 to 15,000
Cauliflower	10,000	2,500 to 5,000
Pepper	4,500	1,000 to 1,500
Eggplant	6,000	1,000 to 2,500

dry but the lower side will keep the soil moist. The burlap may remain until the seed leaves begin to appear but should be removed before the seedlings spindle. This cover prevents washing out of the seeds when water is applied.

Labeling and Care.—It is wise to prepare a small wooden label for each variety just before the seed is planted. The kind of vegetable, the variety, source of seed and date of planting should be inscribed with a hard pencil. Some write these lengthwise the label, but others believe it is easier to read them if printed across the width beginning at the top. Moreover, the inscription is less liable to be obliterated by splashed soil which is often the case with data written lengthwise on a short label.

Uniformity of placing is essential. A common method is to put the label at the left-hand front corner of the flat or series of rows. Thus all plants away from the reader and to the right are of the designated kind. When several varieties are seeded in one flat, or seed of the same variety from more than one source is planted, careful labeling prevents later mistakes.

Flats must be placed in a level position, otherwise the water will run from one side, reducing the germination and growth in that part. With seed which germinates in five to six days it is seldom necessary to add any water if the flats are stacked. The aim should be to maintain a fairly constant moisture content in the soil and not subject the seeds to alternating wet and dry periods.

Seeds differ in their ability to obtain moisture from soil which is getting low in available water but all will germinate more quickly if moisture is plentiful. Celery seed requires a greater soil moisture content for germination than do other vegetable seeds.

A day temperature of 55° to 60° F. is sufficient for the germination of the cool-season crops, but 70° to 75° F. is more desirable for those of the warm-season group. Night temperatures can be 5° to 10° F. cooler than those in day time.

Effect of Size of Seed.—This varies with the kind of vegetable and apparently also with the variety. Tests of the same vegetable by different experimenters have sometimes given conflicting results. The real small and immature seeds frequently fail to germinate and automatically remove themselves from consideration. Some experimental work indicates that a difference in earliness, growth and therefore greater yielding power disappears as maturity approaches, while other tests show that it is carried on through the season.

The grower need not be concerned about the size of the seed he plants, if it fulfills the other requirements set up for good seed. Weak seedlings are culled out in the process of transplanting plants from the seeded row, and in field plantings the thinning process, if practised, gets rid of the poor plants.

There is no relation between size of seed of vegetable kinds and the rapidity of germination. Radish seed is smaller than pea seed and larger than that of carrot, but germinates more quickly than either.

Frame Seedings.—Planting distances of frame-matured crops are less than in the field where cultivation is needed. Radishes are seeded 1 inch apart in rows spaced 4 inches for the small-topped varieties and 6 inches for those producing larger leaf-growth. Rows of carrots are seeded 6 or 10 inches apart and thinned to about a 1 inch stand. Double rows 2 inches apart and 10 to 12 inches between pairs is another common method. Kohlrabi can be planted in rows 6 to 8 inches apart. Lettuce is started in closely-spaced rows and then transplanted to a 6 by 6 to 10 by 12 inch spacing.

Spinach is seeded rather thinly in rows 4 to 8 inches apart. Beets may be transplanted or seeded in the frame. Rows are 5 to 6 inches apart and plants 2½ to 3 inches in the row. Cucumbers

are a popular frame crop. They are usually started in pots, bands or berry baskets in the greenhouse or another hotbed and set very carefully without injury to the roots. A stand of 3 or 4 to the hill is best. A hill is placed in the center under each sash. The plants may be grown singly in smaller containers in which case the plants are spaced about a foot apart down the center of the frame. Muskmelons, summer squashes and watermelons may be grown by this same method, or any of these seeded in place and thinned. These cucurbits make excellent use of the rich soil in a manure-heated hotbed after it is spent.

Outdoor Plantings.—It is impossible to provide the ideal conditions that can be given under glass, but the same requirements for germination hold and they should be met as far as possible. An effort should be made to have the seedbed well prepared so that the soil is mellow and loose enough to provide good aëration, yet firm enough so it will not dry out. In the development of an adequate root system the tilth of the seedbed is a very vital factor. In a poor seedbed there may be an early death of part of the root system in the upper richer layer of soil, with resulting injury to the growth of the plant. This matter of good tilth is of special value in the case of the larger seeds such as some of the beans which must raise their cotyledons above ground. The Scarlet and White Dutch Runner beans and peas are examples of the larger seeds whose cotyledons remain below the surface of the ground.

Heavy garden soils may be lightened by working in sand, or finely screened coal ashes. These have little fertilizing value but exert a loosening effect. Growers situated near blast furnaces may use pulverized slag. Since slag has considerable neutralizing value, it should be used with caution on soils of limestone origin or those to which rather heavy amounts of lime have been applied.

Plowing under of crop residues, manure, or green manure crops which increase the supply of organic matter in the soil, also aids in lightening heavier land.

Soil in good tilth contains multitudes of small air spaces, many forming somewhat continuous channels through which gaseous exchange takes place between the soil and air above. The finer and looser the soil the greater the percentage thus occupied. The small pores hold water while the large ones provide for aëration and percolation or drainage. The teeming bacterial life in the soil and the root activity constantly change the composition of the soil air. Temperature, water content, and gaseous diffusion all act to cause movement of air in the soil. The composition of the soil air is quite different from that above the surface. There is less than the 20 per cent of oxygen and more than the usual 0.03 per cent of carbon dioxide of the above ground atmosphere accord-

TABLE 4.—PLANTING AND YIELD DATA.

Crop.	Approximate No. of seeds an ounce.[1]	Seed for 100 feet of row.	Seed for one acre.[2]	Depth of planting (inches).[3]	Time before ready for use.[4]	Probable yield from 100 feet of row.[4,6]
Artichoke, seed	600	½ oz.	6 oz.	1	12–18 months	150 buds
Artichoke, plants	....	17	900–1100	....	5–12 months	150 buds
Asparagus, roots	....	50	6,000–11,000	5–10	2–3 years	50 pounds
Bean, bush snap	100	1 lb.	30–90 lbs.	¾–1	40–65 days	1½ bushels
Bean, bush lima	20–70	1 lb.	50–100 lbs.	1–1½	70–90 days	15 quarts (shelled)
Bean, pole snap	100	¾ lb.	25–60 lbs.	¾–1	60–80 days	2 bushels
Bean, pole lima	20–70	½ lb.	20–50 lbs.	1–1½	80–120 days	15 quarts (shelled)
Beet	1,500	1 oz.	8–12 lbs.	¾–1	45–80 days	3 doz. bunches or 2 bushels
Broccoli, sprouting[5]	10,000	⅛ oz.	3–4 oz.	½	90–100 days	100 pounds
Brussels sprouts[5]	8,500	⅛ oz.	3–4 oz.	½	90–120 days	30 quarts
Cabbage[5]	7,500	⅛ oz.	3–4 oz.	½	85–120 days	200 pounds
Cabbage, Chinese	9,500	⅛ oz.	1–2 lbs.	½	80–100 days	75 heads
Cardoon	650	½ oz.	....	1–2	5–6 months	50 stalks
Carrot	23,000	¼ oz.	2–4 lbs.	½	65–80 days	100 bunches or 2 bushels
Cauliflower[5]	10,000	⅛ oz.	3–4 oz.	½	95–140 days	60 heads
Celery[5]	80,000	⅛ oz.	2–3 oz.	⅛	120–150 days	200 stalks
Celeriac[5]	80,000	⅛ oz.	2–3 oz.	⅛	125–140 days	100 pounds
Chervil	15,000	½ oz.	....	¾–1	40–60 days	60 bunches
Chicory	26,000	¼ oz.	4 lbs.	½	5–6 months	2½ bushels
Collards[5]	7,500	⅛ oz.	4 oz.	½	100–120 days	30 pounds
Corn salad	13,000	⅛ oz.	10 lbs.	½–1	40–60 days	30 pounds
Cress, upland	13,000	⅛ oz.	....	½	30–40 days	
Cress, water	150,000	½ oz.	....	Surface	60–70 days	
Cucumber	1,000	½ oz.	2 lbs.	1–2	60–90 days	100 pounds
Dandelion	35,000	⅛ oz.	2–3 lbs.	¼–½	6–12 months	100 plants
Eggplant[5]	6,000	⅛ oz.	4 oz.	¼–½	120–150 days	120 fruits

Endive	26,000	⅛ oz.	1–3 lbs.	½–1	60–90 days	75 plants
Garlic, cloves	....	1 lb.	250 lbs.	1–2	120–150 days	2 bushels
Horseradish, roots	....	100	17,424	3–4	8 months	70 pounds
Kale	9,000	⅛ oz.	1–2 lbs.	½	60–90 days	200 pounds
Kohlrabi	8,500	⅛ oz.	4 lbs.	½	50–90 days	80 pounds
Leek	11,000	⅓ oz.	4 lbs.	½–1	120–150 days	300 stalks
Lettuce	25,000	⅛ oz.	1½–3 lbs.	½	60–90 days	50–90 pounds
Muskmelon	1,000	¼ oz.	1–3 lbs.	1–2	90–120 days	60–90 fruits
Mustard	15,000	⅛ oz.	2–3	¼	60–90 days	2½ bushels
New Zealand spinach	350	1 oz.	8 lbs.	1–2	60–100 days	100 pounds
Okra	450	1 oz.	8 lbs.	1	90–140 days	900 pods
Onion, seed	9,500	½ oz.	4–5 lbs.	½–1	130–150 days	120 bunches green or 2 bushels dry bulbs
Onion, sets	....	1–2 lbs.	20–25 bu.	1–2	60–120 days	120 bunches green or 2 bushels dry bulbs
Orach (bractless seed)	4,500	2 oz.	15–25 lbs.	½–1	35–50 days	3–4 pounds
Parsley	18,000	⅛ oz.	3 lbs.	⅛	65–90 days	90 bunches
Parsnip	12,000	¼ oz.	3 lbs.	¼–½	125–160 days	2 bushels
Pea	50–230	1 lb.	60–100 lbs.	1–2	40–80 days	2 bushels
Pepper[5]	4,500	⅛ oz.	3–8 oz.	¼–½	100–140 days	300 fruits
Potato, white	....	5–8 lbs.	20–25 bu.	4	80–140 days	3 bushels
Potato, sweet	....	75 slips	9680	3	140–160 days	3 bushels
Pumpkin	100	½ oz.	2–3 lbs.	1–2	60–140 days	75–100 fruits
Radish	4,000	½ oz.	10 lbs.	1	20–75 days	100 bunches
Rhubarb, roots	....	33	2420	2–3	1 year	300 stalks
Rutabaga	12,000	⅛ oz.	1–2 lbs.	½–1	90–100 days	100 pounds
Salsify	3,000	1 oz.	8 lbs.	½–1	140–160 days	2 bushels
Spinach	3,000	1 oz.	10–20 lbs.	½–1	30–60 days	80 pounds
Squash	100–300	½ oz.	3–4 lbs.	1–2	120–160 days	60 fruits
Sweet corn	110–220	1 oz.	6–12 lbs.	1–2	60–100 days	8 dozen ears
Swiss chard	1,200	½ oz.	6–8 lbs.	1	50–120 days	50–100 pounds
Tomato[5]	11,000	⅛ oz.	2 oz.	¼–½	100–140 days	4 bushels
Turnip	13,000	⅛ oz.	1–2 lbs.	¼–½	45–90 days	2 bushels
Watermelon	225–300	¼ oz.	1 lb.	1–2	100–130 days	25–40 fruits

1 Varies with variety and sample.
2 Varies with spacing and seed treatment.
3 Deeper as season advances.
4 Depends on growing conditions and variety.
5 Seed rates are those needed to produce plants.
6 See crop discussion for acre yields.

ing to the type of soil, its supply of organic matter, physical condition, depth and the amount of root growth it is supporting.

The depth of planting will vary with the kind of seed, the soil, its moisture content and the season of the year. Field plantings are usually at greater depth than greenhouse plantings of the same kind of seed. In early spring, when the supply of moisture in the soil is great and the temperature of the upper layer low, seeds may be planted shallower than later in the summer, when germination might be seriously delayed if they were close to the surface. On soils of the sandy types, which dry out more quickly than the silt loams and clays, it is necessary to plant seeds at greater depths. When irrigation can be supplied, shallow planting is possible. Small seeds are scarcely covered. Seeds which do not push their cotyledons above ground and also those of the monocotyledonae may be planted more deeply. The proper depth of seeding for the various crops is suggested in Table 4.

A layer of sand, leaf mold or granulated peat moss may be placed directly over the seeded row in small plantings. This acts as a mulch and once moistened prevents the soil from drying beneath it. For delicate seeds, and in soil which has a tendency to crust, this will materially help in getting a good stand.

The date of seeding will vary with different seasons. If the land is prepared and a period of rather settled weather comes on it is usually worth taking a chance on a small seeding a little ahead of the normal planting date. If a freeze or frost destroys the crop only the cost of the seed and the labor of putting it in is forfeited. The land will usually still be in shape for another planting. If the venture comes through safely an extra early crop is the reward.

Soil temperatures can serve as a guide to the proper time for planting. It is true that germination of both cool- and warm-season crops will be better and quicker at higher than at lower temperatures. However, when soil temperatures have risen to between 45° and 50° F. good germination can be obtained with seed of cool-season vegetables. Planting of the seed of warm-season vegetables is best delayed until the average daily soil temperature is about 65° F. at the depth the seed is to be placed.

Most gardeners, whether growing for home or market, will want to work in plantings of the different vegetables through the season as space becomes available, until there are not sufficient days left to mature a crop before fall frosts. In some sections plantings can be made in the fall for harvest during the winter and spring months.

Planting Tools.—If the *seeding* is done *by hand* a furrow of proper depth may be opened by repeated pressing of the loosened soil

with the back straight edge of a rake along a tightly stretched garden line. The seed may be shaken from the seed packet or an envelope in the same manner as described in the planting under glass. The larger seeds are often spaced by dropping them with the fingers. A uniform distribution in the bottom of the furrow should be the aim. A rake, hoe, or the hands, in the case of short rows, will serve to cover the seed with the right depth of fine soil.

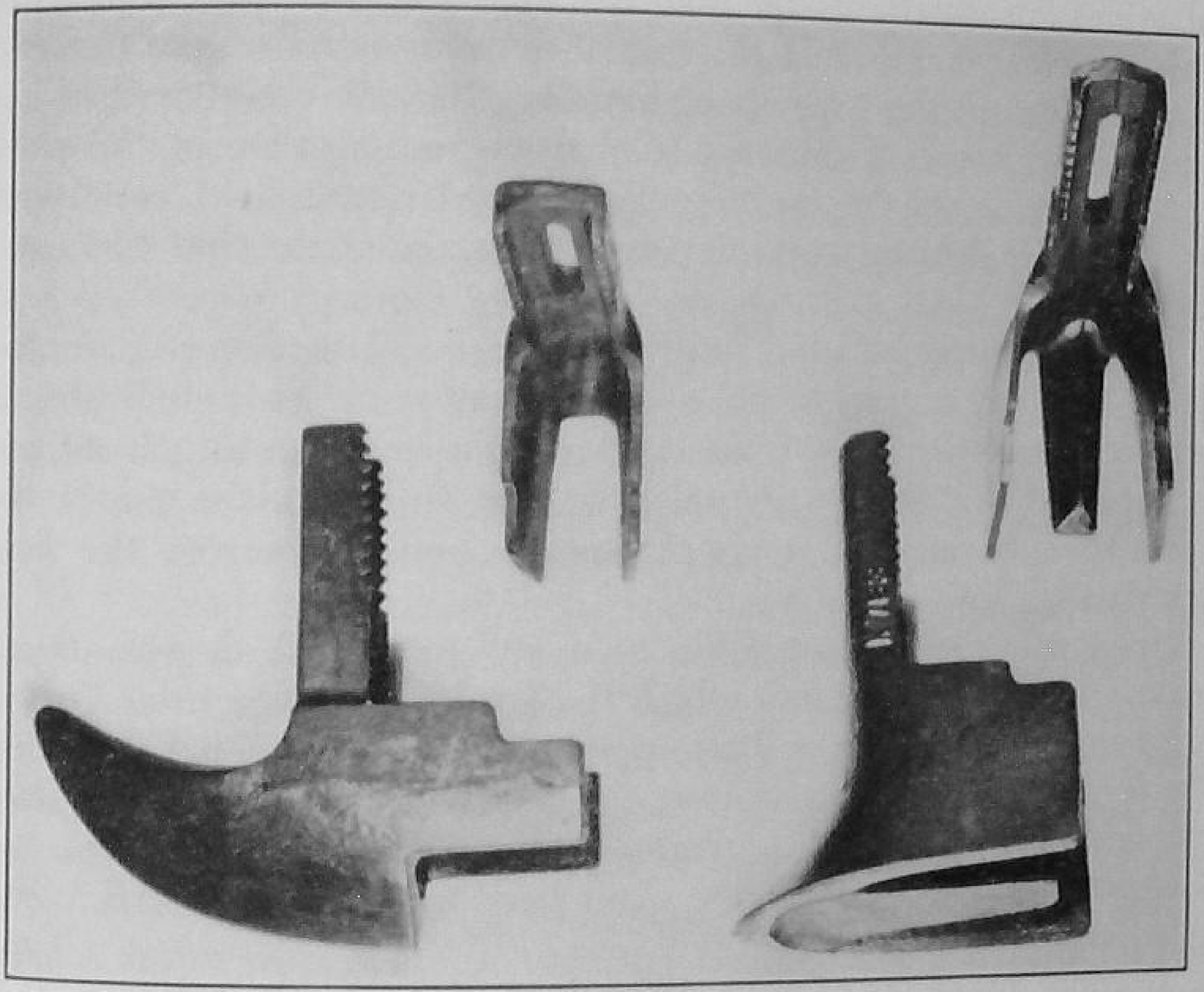

FIG. 14.—The furrow-opening plow on the left lets the seeds drop in a single line. That on the right scatters them in a 2-inch band.

Avoid putting lumps of soil or stones on top of the seed. A final step is to firm the soil well about the seed either by walking heel to toe along the row or by tamping with the flat side of a hoe.

A seed drill does the above mechanically. It opens the furrow to the adjusted depth of the plow, distributes the seed, covers it, firms the soil about the seed, and makes a mark parallel to the seeded row. If the initial row is carefully planted, a series of very straight rows is possible. This is an aid in cultivation since much closer work can be done than if the rows are wavy.

There are many types of drills which differ mainly in the means by which the seed is distributed. Some give a fairly constant flow of seed while others drop each seed at a suitable interval. Since some vegetable seeds are odd-shaped more than one may

drop at the same time. Precision planters meter the seed out at pre-determined uniform places in the furrow. Peas and beans can be handled easily in their natural condition. Onion, lettuce, carrot, tomato and many others have been pelleted. This is seed which has been coated with 10 to 30 times its weight of some inert material such as bentonite clay. These uniform-sized rounded pellets can be dropped at specific spacings provided the tube carrying the seed from the plate to the plow is smooth. Such plantings are usually closer than the final stand is to be but since only one plant is at a place the cost of thinning is reduced. The cost of pelleting and the expense of handling the increased weight are offset somewhat by a decrease in thinning costs. One of the principle deterrents in the use of pelleted seed under field conditions has been the delayed germination in comparison to that of naked seed.

Seed drills may be used singly as in a hand seeder or mounted in multiple on a tractor, on a seeder frame, or on a bed shaper where furrow irrigation is used. Multiple-row planting is an aid to future tillage where several rows are to be cultivated at the same time, because all rows planted in one trip across the field are parallel.

Opening plows are available in many sizes and shapes. Some make a narrow furrow into which the seeds drop in a line. Others are 2 or 4 inches wide and equipped with a horizontal bar within the furrow opener. This scatters the seeds in a broad band. They are adapted especially for seeding onion, radish, and carrot but are useful also in sowing open plant beds of tomato, cabbage, and other crops.

Outdoor plantings of seed differ from those under glass in that the seed is not soaked down always after planting. If the soil is of proper moisture content at the depth the seed is planted the firming of the soil will enable germination to take place. When the soil is dry, water must be applied if no rain is expected. Where furrow irrigation is practiced water can be supplied to the seeded rows by subbing without causing a crust over the seeds.

A beating rain or the use of too much irrigation right after seed is planted is often disastrous on crust-forming soil. If irrigation is carefully used it may serve to keep a crust from developing above the seeds and thus help them to get through. Many times it will be found expedient to loosen the top surface of soil with a rake to break a crust before the seedlings appear. A crust-pulverizing tool consisting of a circular brush of a single line of slightly flexible wires will be found suitable for this operation on many soils.

In the home garden where a hose is usually handy the soil may be gently sprinkled and kept from baking, or burlap may be laid

over the row and water applied to it. As soon as the seedlings begin to push through the surface the burlap must be removed.

Thickness of Planting.—With the increased cost of hand operations there is a tendency among growers to regulate more carefully the thickness at which seed is sown to avoid the cost of thinning. Knowing the viability of the seed, the time of season and the condition of the soil the rate of seeding can be adjusted so that an adequate stand will be secured except in the event of quite unexpected weather conditions. The quantities of seed needed to plant 100 feet of row or an acre are suggested in Table 4.

Thick seeding usually insures a good stand and so when conditions for germination are poor or the seed is a kind which takes a long time to sprout more is seeded than otherwise. In soil that does not give way easily, crowding results in delayed maturity or a misshapen product in the case of crops like carrots, beets and onions. Greater loss from disease is often a result of too thick a stand. Thinning, though costly, gives a chance for selection and results in greater uniformity. The seed of beet is really a fruit containing several seeds. Thus several seedlings may arise at one spot and thinning be a necessity. Whenever a vegetable crop has to be thinned it is essential that the operation not be delayed too long or a serious check will be given the plants which remain.

Lettuce, endive and rutabaga are examples of crops which require spacings of 6 to 12 inches. Seed must be planted more closely than this to be certain of a stand. The removal of most of the surplus plants is often done with a hoe, leaving just 1 or 2 at a place to be hand-thinned. Machines have been developed which have a series of adjustable rotating blades. These remove all but the plants at the desired places. On soil that is free from stones, trash, lumps, and is not too moist, this labor-saving tool does a quick and satisfactory job. It needs to be followed by some hand thinning to remove any extra plants left at each place.

Thick seeding is probably justified in crops that are likely to suffer severe injury from insects. The vine crops which are attacked in their seedling stages by the striped cucumber beetle and the squash vine borer may be planted thickly. When danger of further loss is about over, the hills may be thinned to the proper stand.

In certain sections of country where the season for growth is long enough some crops are seeded directly in the field rather than plants being grown and transplanted. If direct seeding is done, cabbage, broccoli and cauliflower are planted at the rate of 1¼ to 2 pounds, pepper at 3 pounds and tomato at 1/3 pound per acre. The check in growth occurring with transplanting is avoided so a later sowing date is possible. The spread of contact

diseases such as mosaic is minimized. Sometimes germination problems are encountered because of poor soil conditions. The control of insects and foliage diseases on young seedlings in a large field planting may be more difficult than where the seedlings are concentrated in a plantbed.

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Chapter 7

PRODUCING PLANTS

WELL-GROWN plants are the forerunners of profitable yields. To produce the ideal plant requires experience and careful attention to the adjustment of the environment about the young plant to changing weather conditions.

The *ideal plant* is one which shows stocky, sturdy development. It must not be spindly, leggy, or too succulent, nor have been held back too long in growth to await desirable field conditions. The young plant should be free from disease, and have developed a compact root system which will carry a good ball of soil to the field.

The production of plants under more or less controlled conditions has a number of advantages: (1) By bringing in an early crop it lengthens the period of production and gives a harvest while prices are high; (2) enabling the grower located in a section of short growing season to get a profitable yield from the very tender crops like eggplant, muskmelon and lima bean, or to increase his yield from any of those of the warm-season group. Three other gains which apply to plants grown under glass for spring transplanting or in the outdoor seedbed for late spring or summer setting are: (3) The possibility of growing two or more crops on the same land; (4) greater ease of providing satisfactory growing conditions for young plants, and protection against injury from insects and diseases; and (5) a saving of costly seed.

The choice of vegetables to grow for field transplanting depends on the facilities available and the probable market value of the resulting product. It is obvious that a plant which produces a single marketable unit of low value like beet or kohlrabi cannot be given the same care as the more valuable cauliflower and cabbage, or those crops which give a number of units for use like tomato, pepper and eggplant.

Whether the plants should be grown in a heated bed, coldframe, or open plantbed varies with local climatic conditions, and whether the crop is for a very early market, for canning or for harvesting late in the season.

Growing any considerable number of early plants requires a fair-sized outlay for equipment. The sash necessary to produce plants for an acre of each of several common crops is given in Table 5.

In recent years the number of early plants raised for sale to vegetable growers has increased at a tremendous rate. There appears to be a good future in this phase of the vegetable industry for men who master the art of plant production. It seems ideal to be able to place an order for plants and have them arrive when you are all ready to put them in the field. Thus the exacting care of the weeks of glass management is avoided. This is an excellent solution providing the requirements suggested for good seed in Chapter 5 and the above ideals of plant production have been fulfilled.

TABLE 5.—SASH REQUIREMENT FOR PRODUCTION OF PLANTS.

	Field spacing.	No. of plants an acre.[1]	Final spacing in frame (inches)	No. of plants to a sash.[2]	No. of sash needed to grow plants for an acre.[3]
Celery	3′ x 6″	29,040	1½ x 1½	1120	26.7
Lettuce	18″ x 12″	29,040	1½ x 1½	1120	26.7
Cabbage	30″ x 18″	11,616	1½ x 1½	1120	10.4
Tomato	3′ x 4′	3,630	2 x 4	324	11.2
Melons	6′ x 6′	1,210	4 x 4	157	7.7

[1] Obtained by dividing 43,560 by the product of the two distances expressed in feet or decimal fractions of a foot.

[2] Based on plants growing in soil of frame or in bands of wood or paper. If flats are used the number will be somewhat less due to space occupied by sides and ends of flats.

[3] No allowance made to permit rejection of poorer plants at time of setting in the field, or possible loss from unexpected causes.

Plants may be obtained from a local greenhouse plant grower, from one of this type at a distance, or they may be field-grown in sections with an earlier spring, *i. e.*, southern-grown plants.

At the local plant grower's the buyer may see the plants, obtain information as to the strain used, and whether seed and soil have been treated for disease prevention.

When the buyer makes his purchase from a distance without seeing the plants he depends on the integrity of the plant grower to provide him with the quality of plants he would have tried to have raised himself. Many states have laws requiring that the plants be inspected and certified as to freedom from insects and diseases either before shipment or before they can be set out in the field at destination. Thus the purchaser is protected and the transmission of pests between areas is prevented.

Much of the mass production of plants in the milder areas to the south is on a contract basis with canning companies, distributors of plants, or large vegetable growers located further north.

Transplanting.—A stocky growth of the young plant is dependent upon sufficient room for expansion. The more frequently the roots are disturbed and the root hairs broken off the more the plant will be checked. If this check occurs when considerable size of top has been reached the yield will be materially reduced. It would seem, therefore, that best success would follow the planting of seed in a pot or container which would give plenty of room for growth and allow a large ball of soil to be put in the field with no injury to the roots. While this is true, the space required to carry out this scheme would be prohibitive when many plants are grown. The principal reason for transplanting is the economical use of space. Plants are usually transplanted only when they begin to crowd.

TABLE 6.—CLASSIFICATION OF CERTAIN VEGETABLES ACCORDING TO THEIR RESPONSE TO TRANSPLANTING. (AFTER LOOMIS.)

A.	B.	C.
Easily survive transplanting.	Requiring care in the operation.	Not successfully transplanted by usual methods.
Beet	Carrot	Corn
Broccoli	Celery	Cucumber
Brussels sprouts	Eggplant	Lima bean
Cabbage	Onion	Muskmelon
Cauliflower	Pepper	Peas
Chard	Salsify	Snap bean
Lettuce		Turnip
Tomato		Watermelon

The crops in group "C" will usually suffer a very serious check if the roots are disturbed. The cucurbit members of this group can be seeded in a row and then placed in containers before the first true leaves have appeared.

In the process of moving the seedlings to a wider spacing the ends of the long roots are broken off. This check results in the growth of side roots which make it possible later to move a larger ball of soil about the roots than would otherwise be the case and has led in part to the idea that transplanting was beneficial. The degree of check to a transplanted plant is about in relation to its age. Seedlings whose first true leaves are just beginning to show can be transplanted with little check, since the effect of this shift will be outgrown by harvest. The reduction in growth of the plant following transplanting is about proportional to the degree and length of time that the plant is operating on a reduced water supply. This is primarily a root relationship, though it is influenced by the conditions affecting transpiration from the top. According to Loomis

there are three factors concerned: the proportion of the root system retained in the process of transplanting; the effectiveness of the retained roots in absorbing water during the first few days after transplanting, and the rate of new root formation.

It will be noted that, except for turnips, the crops in class C have large seeds. The seedlings of these crops are large in comparison to the part of their root system that can be readily removed from the soil for transplanting.

Vegetables vary in the degree of suberization of the older roots which affects their ability to take in water. Rapidly growing vegetables will suffer more than those like celery, which make a slow growth.

Preparation of Flats or Beds for Transplanting.—The soil for producing early plants must be richer than that used for seeding purposes alone. It does not pay to try to grow plants in poor soil. Too rich a soil, on the other hand, will give an undesirable succulent top growth with a relatively weak root system. The amount of rotted manure, leaf mold or muck and sand which are added depends on the type of loam used and the method of composting. Equal parts of sand, loam and manure make an ideal mixture. A mixture of this sort is loose and friable. It provides enough spongy organic matter to aid in water retention. Ample minerals are available for the little plants and good aëration is furnished for the roots. Since the soil is loose it is possible to lift the plant with its root system fairly intact for planting in the field.

Soil disinfection by one of the methods described in Chapter 13 is desirable to control diseases and weeds in any soil used for plant growing.

Flats of soil to be used for transplanting seedlings are prepared as described in Chapter 6 except that the soil is firmed to a greater extent throughout than in their preparation for seeding. Thus the holes which are punched to receive the plants will retain their shape. Proper moisture content helps in this respect. It is essential that the soil be level with the top so that the spotting board may fit snugly against it. Otherwise when the dibble is extracted from the opening in the board a clean-cut hole will not be obtained.

Various types of *spotting* boards are used to get accurate spacing and save time. The simplest type is a flat board with nails hammered through at the points where plants are to be placed. These may be 1½ by 1½ inches; 2 by 2 inches; 3 by 3 inches, or 4 by 4 inches. The board is carefully pressed down over the flat of soil, and when lifted off the nails will leave the proper markings. Then it is necessary to open the holes with a sharpened piece of round wood ½ to ⅝ inch in diameter. This is usually referred to as a dibble, dibber or planting stick. Instead of nails, little blocks of wood may serve, or ¼ inch

square sticks may be nailed to the surface of the board in the form of a grid. These leave an impression when forced into the soil of the flat. Holes are made with the dibble at the intersections.

The spotting board may be of the type with holes bored at the appropriate spacings. The dibble is thrust through each in turn and removed with a twisting motion, which gives a clean hole. Sharpened pieces of wood may be driven through these holes to a uniform length on the other side. The whole board is pressed down on the soil as the one which had the protruding nails. In this case, however, the holes are all made in the one operation. If the soil is too moist it will stick between the pegs as they are lifted from the soil.

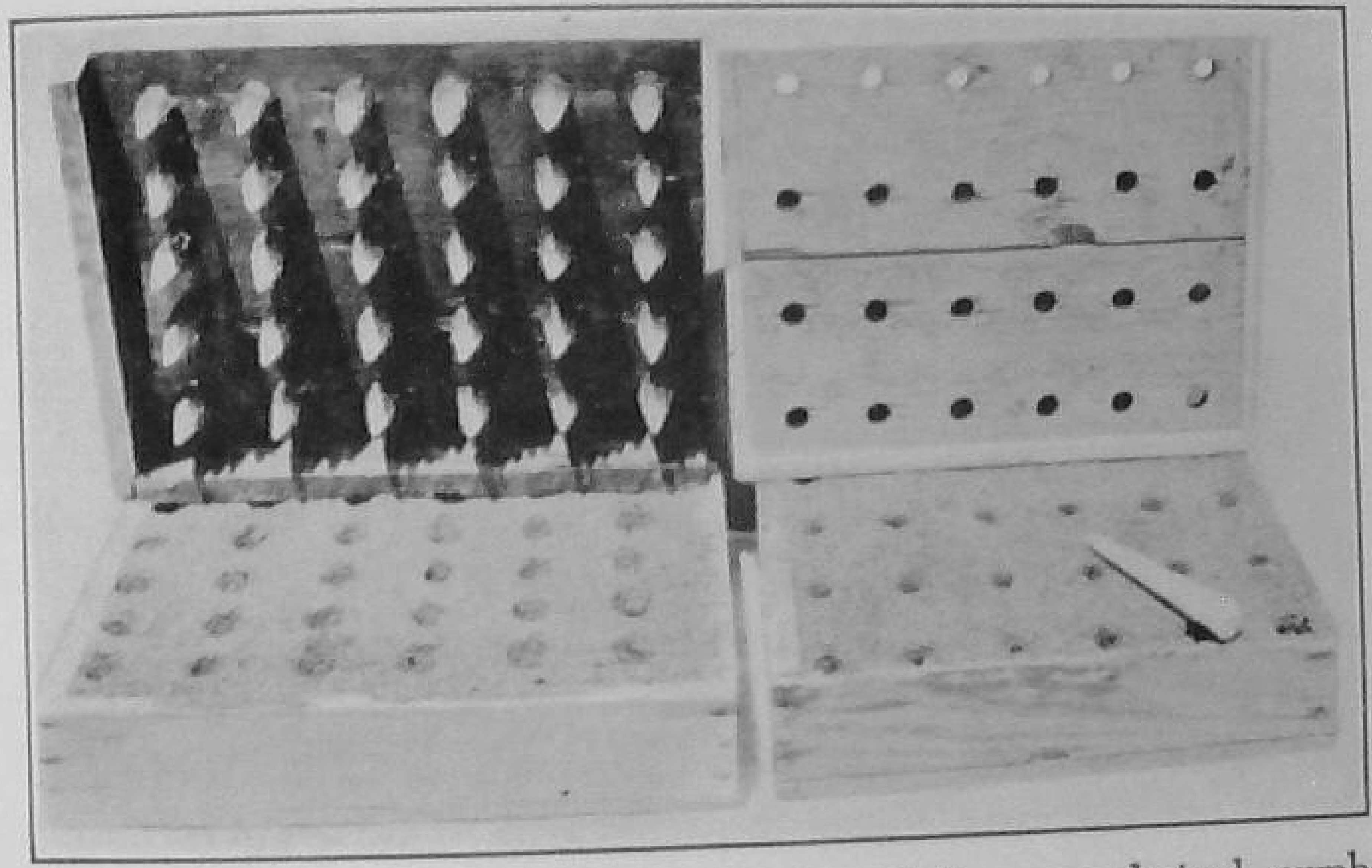

FIG. 15.—Spotting boards may be designed for any desired number of plants to a flat. Projecting pegs make all the holes in one operation. The dibble must be inserted in each opening of the type on the right.

A good sand content helps to prevent this. Whatever method is used the depth of the hole must be in relation to the size of the seedlings being transplanted. A celery seedling would be lost in a hole of suitable size for cabbage or tomato.

The soil in frames is usually marked out by the use of a board whose length equals the width of the bed. This has several rows of pegs and is pressed into the soil just as its smaller counterpart was used on the flat, or it may be the width desired between rows and is marked at suitable intervals so that the seedlings can be laid opposite these marks with their roots in a furrow which has been opened along the edge.

The *spacing* to be given varies with the kind of seedling, its age, the room available for spreading out the plants and whether it will have to be transplanted again. Cabbage, lettuce, cauliflower and celery can usually be shifted or "pricked out" when their first true

leaf is developing, to a 1½ or 2-inch spacing and carried in that to the time for transplanting to the field. Onions and beets are seeded thinly in the row, and the poorer plants removed if they seem too thick. Tomato, pepper and eggplant are given the narrow spacing at the first transplanting and 3 by 3 inches or 4 by 4 inches when they require further room for growth. These crops and cauliflower are helped by the use of pots, bands or other containers which will confine the roots to a definite block of soil and reduce injury in field setting. These may be used at the second transplanting or, if space is available, at the "pricking-out" stage. The soil about seedlings which are to be transplanted should be thoroughly soaked six to twelve hours before the shift is to be made. The tops are easier to handle if dry. This preliminary watering enables the plants to take up plenty of water and be in a turgid condition. It softens the soil so that a good part of the root system can be lifted out with the plant, and is done far enough ahead so that the soil will not be muddy.

A putty knife makes a handy tool for removing the seedlings from the row. A few tappings of the roots against the side of the flat will loosen the soil so that the seedlings may be separated one from another. All those that appear weak or injured should be discarded. If the roots are too long to go down easily into the holes in the new flat they may be clipped off slightly.

Greater ease of spotting seems possible if plants are placed in all the holes in the flat before any effort is made to firm them. All the tops should be laid away from the operator. The plants should be set lower than they previously stood. The top is guided with the fingers of one hand as they press down on the soil while the dibble is thrust in at an angle toward the other side of the plant. It should reach as far down as the bottom of the hole. A little pressure downward and across the seedling will cause the soil to pack tightly about the roots. For firming delicate seedlings like celery and lettuce a small pot label or the thumb and finger are usually enough. *Contact* is the important principle in transplanting. Merely smoothing the soil around the stem of the plant and leaving a large air pocket in which the roots hang will result in a wilted plant which soon dies. Properly transplanted plants will be anchored firmly.

When plants are shifted from a close spacing to a wider one or into pots it is desirable that a very good ball of soil be lifted with the roots. To this end it is best to take them out singly with a small trowel. Root injury is more serious at this stage than at the seedling size.

Care must be exercised in the operation of firming the soil about the plant to avoid squeezing the tender stems. This is more likely to happen with the succulent cucurbit seedlings than with cabbage.

If the main pressure is downward on each side of the plant little stem injury will result.

Following transplanting the flat must be watered well. Newspapers laid over the plants shade them from the hot rays of the sun when it is not possible to spread the flats out on the floor or benches of the potting room until the next day. Rapid transpiration from the leaves of the newly transplanted seedlings should be prevented.

Fig. 16.—Transplanting lettuce. The soil is pressed tightly against the roots of the seedling with the point of the dibble.

Labels ought to be made up for each flat or part flat if one contains two different varieties. The date of transplanting is added below the information already on the label of the seeded flat. Thus a complete history of the plants is had at a glance. Dates of subsequent transplantings including that to the garden may be added. If an unsatisfactory condition arises as harvest approaches it is possible to check back by looking at the labels. Instead of blaming the seed the label will perhaps indicate that there was a difference in the way the plants were handled before they went to the field.

Use of Containers.—The idea back of the use of containers for plants is to enable the grower to move to the field good-sized plants or those difficult to transplant. With less injury to the roots, the plants take hold at once. There is no question about the gain in earliness to be obtained with vegetables by using containers. The problem is whether glass-covered space is ample enough to permit seeding directly in the receptacles and which type of container is the best to use.

Paper pots can be made by folding strips of paper about and over a block of wood fastened to a bench, and securing the folded end with a tack. Tin cans with a hole punched in the bottom for

drainage may serve as plant receptacles, though it is difficult sometimes to release the ball of soil. A dent on the side may act as a brake to easy extraction.

Pots of conventional shape made of pulp or peat compressed with other materials can be purchased. One form of these is a planting pot, through the side walls of which the roots will penetrate so that the plant is not removed from the pot when it goes to the field.

Clay pots cost more than other types, but since they may be used more than once the initial investment is spread over several seasons. With reasonable care the breakage should not be great. Plants do not develop as well in new clay pots as in those which have been used previously. The new clay takes up some of the nitrates from the soil.

Bands or containers without a bottom can be obtained in wood veneer, paper, thin or heavy cardboard and asphalt-treated paper. A tin can with the solder melted forms a metal band.

Paper bands are probably the cheapest. The disintegration of the paper may make it difficult to handle in the final transplanting to the open. Those made of wood veneer are more satisfactory. They should be soaked in warm water fifteen to thirty minutes before an attempt is made to fold them. Bands may be removed or can be left about the blocks when set in the field as the roots are not impeded in their downward growth.

The amount of nitrates available in the soil within these types of pots and bands varies and is an important factor in proper growth. Those containers in particular which are made of paper may give a stunted yellowish plant. This is the natural sequence to the utilization of nitrates by the microörganisms concerned in the decomposition of the paper. Some paper pots are treated with substances to retard decomposition. Aëration conditions in the soil are influenced by the lightness of the potting soil and in turn affect the rate of nitrate formation. An occasional watering with a solution of 1 ounce of nitrate in 1 gallon of water will correct this yellowish unsatisfactory growth.

Each type of container may present an individual problem in the maintenance of proper moisture conditions. Certainly they differ in the rate at which they lose water. Paper or wood bands may be fitted snugly together so that there is less drying out, but if they are separated to give the tops greater room for expansion, more water will be evaporated.

Pots do not fit closely together, so if there is much air circulation, as in the case where bottom heat is used, more frequent watering may be necessary. Those planting pots which permit the roots to emerge through their side walls may be plunged in sand, light ashes,

peat moss, or other material. This practice should reduce water loss from other pots capable of absorbing moisture from the contained soil.

Not all containers will do equally well under the same set of conditions. Satisfactory results should be possible with any of the various kinds of containers if careful attention is given to the nitrate supply and the maintenance of proper moisture. The initial cost of the pot, the particular use one wishes to make of it, and the number of times it can be used, may be the deciding factors in the selection of the kind of container.

FIG. 17.—Potted tomato plants the same age. That on the left is more desirable. It is stocky, and shows the side shoots developing in the axils of the leaves. The other has had too much warmth and moisture, tending to legginess.

Care of Growing Plants.—Rather uniform environmental conditions are desirable in order that the plant may make a steady continuous growth. To this end the growing conditions are controlled by adjustments in the temperature, ventilation and watering. These are quite interrelated, and a change in one influences the others. The principles are the same whether the grower is using a greenhouse or a frame.

Temperature.—Temperature is regulated by adjusting the supply of heat coming from the boiler, furnace, or greater depth of ferment-

ing manure. The sunlight has a tremendous heating effect on a body of air confined under glass or cloth.

Plants fall into two groups. The cool crops thrive best with a day temperature of 60° to 65° F. and a night temperature of 50° to 55° F. High temperatures for these crops will result in a weak, spindly growth if enough water is at hand. Except for slowing down their growth too much these are unharmed by a lower temperature. However, with celery premature seedstalk production may be expected if the average temperature is even a little below 60° F. for two or three weeks. Warm season crops require a day temperature of 70° to 75° F. and a night temperature of 55° to 60° F. They can stand a warmer temperature with little harm except too rapid development. A cooler range, on the other hand, will retard them seriously.

Ventilation.—Ventilation is a means of reducing the temperature by admitting cool air from the outside. The hot air passes out and carries off the excess moisture. Condensation of water on the under side of the glass should be avoided. Warm, muggy conditions aid the growth of disease organisms. Plenty of fresh air must be given, but direct draughts and chilling avoided. Ventilation on the side away from the wind prevents it from coming directly on the plants.

Moisture requirements of the plants must be carefully watched. Overwatering results in succulent leggy growth which is hard to correct. A good soaking which will go well below the surface and then no more until the plants begin to require some is a better system to follow than frequent light waterings. On the other hand growth will be poor if the soil is puddled and then becomes too dry. Continued wilting exerts a serious retardation to growth which may not be outgrown. On bright sunny days two waterings may be required; on cloudy days possibly none. If a good application is given in the morning the surface soil and foliage will be dry by night. This may prevent frost injury of leaves touching the glass. A dry surface soil is an aid in reducing losses from "damping off." If plants are watered when the temperature is rising, as the old rule advises, this condition of dryness will be obtained.

If transpiration has been too great and more water must be given the plants later in the day, this may be done directly to the soil by drawing the hose along between the plants rather than spraying it on the leaves.

Weed seeds which have not been killed by disinfection will germinate and compete with the vegetable plants, for sunlight, water and minerals. They should be pulled by hand, cut off by scraping with some small hoe-like tool, or by cultivating very lightly with hand weeders. Injury to the roots must be prevented.

Hardening.—Plants are "hardened" or toughened slightly prior to being set in the open. This is accomplished by slowing down the

rate of growth and is designed to prepare the plant to withstand any adverse conditions to which it may be subjected. These may be either a frost or a freeze, chilling, drying winds, shortage of water, transplanting, or high temperatures (bright sunshine).

Withholding water or lowering the temperature are the means best adapted to producing a "hardened" plant. A check in growth from severe root pruning, letting the plant become root-bound, or growing in poor soil would toughen the tissue but would not give a desirable plant.

Hardening is often thought of merely as protection against low temperatures but may be said to be almost equally important against high temperatures. No special effort is made to harden late cabbage plants because in an outdoor seedbed the water supply is usually low in the latter part of June unless replenished by irrigation. Competition for water and nutrients between the plants standing closely together in the row will slow down their growth and to this extent toughen their tisues.

Hardening is primarily to reduce the loss of water from the cells of newly set plants. All the conditions which the plant is hardened to withstand operate in the last analysis on the water content of the cells. When plants freeze, water may move out of the cells and into the intercellular spaces where the ice crystals are formed. However, crystals form sometimes within the cells. In such cases, the injury is severe due to the mechanical effect of the ice on the protoplasm. Many plants can withstand temperatures several degrees below freezing provided ice formation does not take place. Hot drying winds increase the rate of transpiration, and with water absorption at a low ebb through the mutilated root system, the cells of the plant are soon lacking in water.

Internal Changes.—When the rate of growth is reduced carbohydrates accumulate because they are not utilized in the formation of new tissues. This means that when favorable conditions recur growth can start at once. Thus hardening reduces to some degree the delay in recovery from the transplanting process.

Experiments indicate that there are a number of internal changes taking place all of which may play a part in reducing the freezing-point of the cell sap or otherwise increasing the ability of the cell to hold water against the influences which would cause it to move out. The sugar content is increased and the water content decreased with a consequent greater osmotic concentration. Apparently there is a change in the protein constituents of the protoplasm which breaks them into forms less easily precipitated. The water-retaining power of the protoplasm is made greater by an increased amount of pentosans or colloidal matter, and possibly also by a change in acidity. The vicosity and permeability of the protoplasm also may be

altered. This influences water movement and may reduce mechanical injury to the tissues from ice formation.

External Changes.—Plants which have become hard exhibit external changes, varying more or less with each kind. Growth is slow or practically ceases. In general the tissues become tougher and this change in texture often is apparent to the touch or eye. The accumulation of carbohydrates leads to the formation of the reddish-purple pigments, anthocyanins, in the leaves and stems. A paler green color, approaching a yellowish-green is common in hardened leaves instead of the dark green of tender, actively growing tissues. Cabbage takes on a waxy bloom from which water sheds readily. Often the water within the leaf, though drawn into the intercellular spaces, does not freeze unless it is inoculated by the crystals of ice forming in a drop or film on the outside of the leaf.

FIG. 18.—Use of dibble in transplanting cabbage. In the center the soil has been firmed about the stem but the lower roots hang in an air pocket. At the left the correct use of the dibble is shown, as it is pushed toward the plant the soil is firmed against the roots throughout the whole distance. The hole left by the dibble should be filled to reduce drying of the lower areas.

Length of Hardening.—Plants lose their hardiness under good growth conditions in about the same length of time it takes to acquire it. Therefore any great degree of hardiness can be acquired only by continued periods at suboptimum growing conditions, be these moisture, temperature or both.

Plants should be hardened just enough to withstand the particular conditions they will have to meet. Too great a check in growth is not desirable. The tissues will mature and be unable to develop further when conditions change. One to two weeks of hardening is usually sufficient to reduce the rate of growth to the point desired. During this period glass or cloth should be left off frame-grown plants except when it is raining or there is danger of frost. Water may be withheld somewhat. Reduction in the water supply is the way to harden plants in field plant beds.

Field Transplanting.—Every time that plants are taken from one location and placed in a new one the grower has an opportunity to

reject the smaller ones. There is considerable experimental work to justify the opinion that the large stocky plant is the best, provided it can be transplanted without too severe a check. For example, results with Enkhuizen Glory and Danish Ballhead cabbage obtained at the Pennsylvania Experiment Station (Bull. 137) show an average yield of 12.7 tons per acre for small plants, 18.5 tons for ungraded and 21 tons for the large size. It is because of this chance for selection and culling in transplanted plants that the grower counts on but one-quarter or one-third as many plants set in the field as he started seeds.

The space allotted to each plant in the garden varies with the crop, the method of cultivation and the fertility of the soil. Crops of spreading growth need more room than those more upright in their development. On rich soil and in a good growing season the top growth may exceed that under other conditions. If horse or tractor-drawn tools are to be used in weed control, somewhat wider spacing is required than where hand tools are employed. Economical use of land necessitates judgment in the allotment of garden space, but nothing is gained by too close planting. Maturity is delayed when plants are crowded.

When the plant moves from the plantbed to the field or garden it passes from a more or less controlled environment to one in which it must take its chances with the vicissitudes of the weather. In intensive culture irrigation may be relied on to help sustain the plants through this trying period. The gardener can take a number of precautions in the way of cutting down the water loss from the plants during the shift and facilitate their early recovery.

Transplanting may be done on cloudy days, just before a rain is expected, or toward evening. The plants will have time to begin taking hold in their new location before being exposed to the hot rays of the sun. Shingles or boards may be stuck into the soil on the side of the prevailing winds. These tilt slightly over the plants furnishing shade, preventing somewhat the effect of the wind on increasing transpiration, and are often most valuable in the reduction of injurious whipping of the plants by the wind.

Plants should be removed from the seedbed with a good ball of soil around the roots. This does much toward reducing the check. Watering a few hours before digging helps the soil to cling. They should not be dug any longer ahead of resetting than is necessary. The tops often are wet down and the stack of plants covered with wet burlap to delay wilting. "Puddling" or dipping into a thin mud batter is helpful, particularly if there is little soil on the roots of plants which have never been moved from the seeded row. "Puddled" roots must be covered with wet burlap for if this mud once dries hard it is difficult for the roots to survive. Plants are shaded as

much as possible on their way to the field. Plants in well moistened flats can be carried right to the place of planting before they are taken out and thus are less likely to suffer injury from drying.

Holes may be made with a large-size dibble, trowel or even a spade. Opening a shallow furrow is helpful if the plants are to stand close together or if many are to be set. When furrow irrigation is used the water can be run down the furrows before the plants are "mudded in" by pressing the roots into the softened soil at about the water line on the bed.

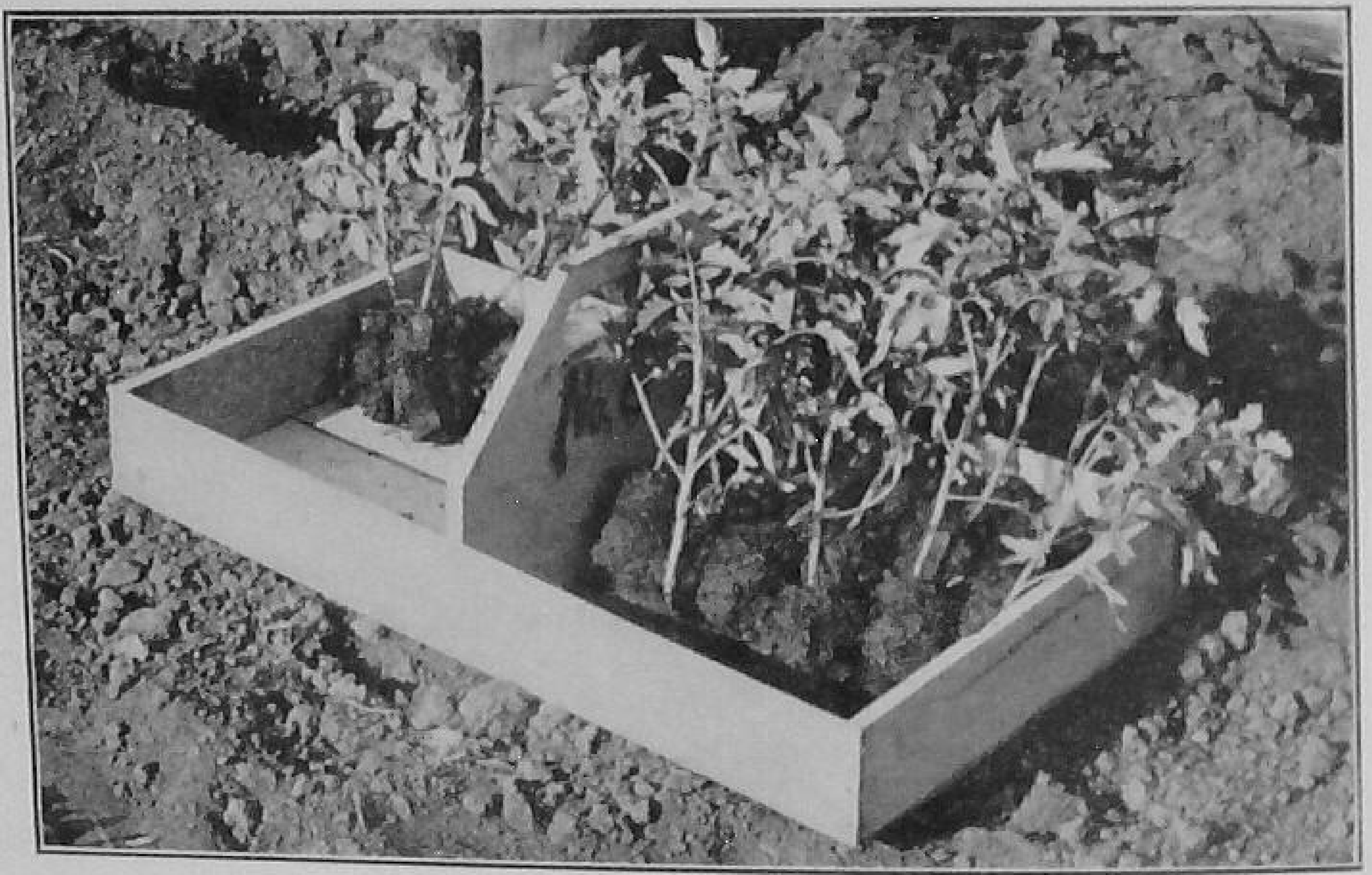

FIG. 19.—This type of carrier is convenient for taking plants from the seeded or spotted row to the field. (Boyle.)

In field setting as well as in earlier transplanting, *contact* of roots and soil is necessary for success. The plant is set more deeply than it stood before, but the center or heart leaves must not be covered. Water may be placed in the bottom of the hole which has been opened for the plant, or may be added on top of the soil about the plant. If this latter is done it is well to pull some loose dry soil over this wet area after it has dried somewhat so that less water will be lost into the air.

The desire to reduce transpiration and conserve water has led to the practice of pruning the tops of plants about to be reset. Plant roots also are sometimes pruned to facilitate putting them into the soil, especially when transplanting machines are to be used. Both top and root pruning add to the check the plant receives from being transplanted. Maturity is delayed and yield may be reduced. The practice of top pruning reduces not only the manufacturing area of the plant, but also the reserve of carbohydrates in the tissues which could have been available for new root formation. It

is best to hold pruning to a minimum and if it does not rain supply the plants with water soon after setting. The field should be checked over after a week or so and all dead plants replaced with new ones.

In large-scale operations the use of transplanting machines is a distinct advantage. Quicker, more uniform and more exact work can be performed. A shoe opens up the furrow. By means of a gearing system, water may be dropped at the desired place and the plant released at the moistened spot. Two blades close in the soil about the plants and rollers or shoes press down, firming it on each side. The plant is solidly in place with water at its roots. Various mixtures called "starter solutions" may be used in transplanting to stimulate rapid growth. Soluble mixtures such as the 13:26:13, 10:52:17 and 15:30:14 analyses are available from commercial sources. They are used at the rate of 3 pounds to 50 gallons of water. Nitrate of soda alone at the same rate in the transplanting water is satisfactory provided the soil on which it is used is not deficient in phosphorus or potassium. From ¼ to ½ pint of the water is released about the roots of each plant. Machines, pulled by team or tractor, are built to plant one or more rows at a time. The plants are either spaced and dropped by hand or placed in clips at appropriate spacings on a wheel or chain from which they are automatically released when they reach the soil. It takes one or two men to each row depending on how close the plants are to stand and how fast the machine travels. Usually someone has to walk behind the transplanter to fill in the skips. Special plant-setting machines are built which obtain their motive power from a small gas engine mounted on the back. A guide wheel runs in a previously opened furrow, and at the same time makes the mark on which to plant the next row. This is adapted primarily for setting plants which stand close together in the row since its speed is far less than the other type. Two boys or men to feed the plants into the clips are all the crew necessary.

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Chapter 8

SOILS AND THEIR PREPARATION FOR PLANTING

MANY types of soils are used for vegetable growing. Production of vegetables for the home and local market is to be found wherever the soil is at all suited to agricultural use. Areas for producing vegetables for distant markets are often located on the soil type best adapted to the crop. A soil which has certain advantages for vegetable production at one season of the year may not be so desirable at another. On a small scale, as in the home garden it is possible to materially change the structure of a soil in a relatively short time. Heavy soils may be lightened by incorporation of a large amount of sand. Working in muck, leaf mold or other organic matter is probably the best way to lighten the heavier classes of soils. In field production this is accomplished over a longer period by plowing under green crops or otherwise increasing the content of organic material. Good crops cannot be expected from land which is not well prepared, not properly handled, below normal in moisture, or unsuited to the crop and season of planting.

The *ideal soil* for all-round production of vegetable crops is one which warms up early in the spring yet retains moisture throughout the season. It should be easy to work, dry quickly after rains, and should not bake nor pack. Excess water should drain away readily yet the subsoil be retentive. It should not be poor in fertility, but this lack may be more easily improved by the use of fertilizers than is the physical condition. The so-called sandy loams which contain about 25 per cent of the coarser sizes of sand and also 20 to 50 per cent of silt and clay, most nearly fit this ideal, and therefore are most popular for cropping with vegetables.

A good top-soil underlain with a hard pan which prevents both the upward and downward movement of water would scarcely prove of much value. This factor with others has led soil scientists into a consideration of the horizons or layers of soil and their relation one to the other. This appears to be of more vital value than does a mere study of the kind of rock from which the soil was derived. Soils are mineral or organic in nature, the former having been developed from the products of rock weathering and biotic life. They contain less than 20 per cent organic matter. Subsequent erosive agents, wind or water, may transport this

material considerable distances from its place of origin. Sand, silt loams and clays are of this nature. Organic soils, the peats and mucks, owe their origin to the accumulation of partially decomposed plant materials under poorly drained conditions in depressions such as old lake beds and swamps.

Sands and Sandy Loams.—Sands and sandy loams are the soil classes especially adapted for early crops. They dry out quickly in the spring and warm up more rapidly. The two differ in the amount of silt and clay which they contain. Building up with organic material is a requisite to successful cropping, especially with the former group. The larger particles of these soils give a structure which supplies good aëration. As the humus content is increased these soils suffer less from mid-summer droughts and their adaptability to all-season cropping is increased. A subsoil retentive of moisture is an advantage since the roots may grow down through it. The presence of a fairly high water-table also helps the sandier soils. While naturally rather poor in fertility these soils will respond to applications of commercial fertilizers. Because of their porous nature nitrates are rather quickly lost by leaching. Potash also is in need of constant replenishment. Well-shaped and smooth root crops can be produced on these soils.

The Silt Loams and Loams.—The silt loams and loams are the predominating soil classes throughout the country. They differ from the sandy soils in that, while not workable so early, their ability to hold moisture is an aid to the production of long-season crops for the cannery or for fall harvest. Their fine texture makes them suitable for vegetables grown for their fleshy root parts. They are in general very fertile and easy to work when well supplied with organic matter.

Clay Loam and Clay Soils.—Clay loam and clay soils are retentive of moisture but at the same time usually poorly aërated because of the very small size of their particles. They are slow to dry in the spring but may be aided in this particular by ridging in the fall. These kinds of soils are adapted primarily for late crops of corn, tomato, cabbage and the like with which earliness is not a factor, but where a soil of high fertility and moisture content is essential to carry the crop through the periods of dryness to large yields.

Soils which contain much clay must be handled with great care. If they are plowed, worked or tramped upon when too wet the arrangement of the particles is upset, which is termed "puddling" or deflocculating. The soil breaks into hard lumps or clods when it is dry. This condition is corrected with difficulty, but may be overcome gradually by the use of organic matter and proper tillage practices. These soils when low in organic content bake and

crust when they dry after rains and make it hard to obtain a good stand of many crops. Usually they respond less to applications of potash than to nitrogen and phosphorus.

Muck or Peat Soils.—Most of the organic soils in the United States are technically peat soils although many are called muck. Their content of 20 to 85 per cent of combustible organic matter gives them a friable consistency. Muck soils are rich in nitrogen, low in phosphorus and potassium when newly cleared. They have a high water-holding capacity. Because of their moisture content, their inability to give off quickly at night all of the heat stored up during the day, and their low-lying position they are subject to late spring and early fall frosts. Although short-season soils and suffering in the dry summer from surface blowing they are ideal for the summer production of the salad crops, celery and lettuce which require plenty of water and nitrogen for a crisp tender growth. Onions grow well on muck because the light nature of the soil permits the bulbs to push each other about and develop without injurious crowding.

The more decomposed or black mucks are more valuable for vegetable growing than the brown. Some newly cleared and drained swamps must be worked for several years, and often treated with lime and manure before vegetables will thrive on them.

Preparation for Planting.—No amount of surface scratching between the rows of plants can make up for poor preparation of the soil. On the other hand, if the soil is properly plowed and harrowed until all trash is turned under and the upper 6 to 8 inches well worked up, weed control and good tilth will be a relatively simple proposition.

The slope of the land determines in some respects the earliness of preparation. In general, sloping land is better drained and if sloping to the south is exposed more fully to the sun, and protected from the cold north winds. If natural drainage is not good it may be necessary to provide for artificial removal of excess water. Land that is drained not only warms up earlier in the spring but as air moves in to fill up the pore spaces vacated by the water, aëration is increased, affecting the growth of roots and the activity of bacteria. Open ditches interfere with garden operations, are wasteful of land, and costly in up-keep. Burned tile is to be preferred. Drain tile of 4-inch diameter is laid with a fall of 3 to 4 inches per 100 feet at a depth below the frost level, which usually brings it 2½ or 3 feet below the surface. A line of tile is placed every 40 to 100 feet, depending on the contour of the land, the kind of soil, and the amount of water it will be necessary to remove. When the soil is underlain with a hard pan as in some of the sections of Florida, drainage is necessary. In a dry spell, however, the system

is reversed and water fed into the tile, thus accomplishing subirrigation.

Plowing.—The crop residues of the previous crop will be turned under more easily if a disk harrow is run over the area first. Plowing is not essential on all soils. Thorough disking may be enough to put the soil in good condition for planting. Plowing is the best method on the other hand in those soils which need to be deepened and improved by putting lime, fertilizer and organic matter into the deeper horizons.

The time of plowing will depend on the cropping scheme and climate. Where the ground freezes or remains too wet and cold for cropping during the winter, there is a choice between fall or spring plowing in preparation for the next season's crops. In the West and Southwest plowing is done at all times of the year whenever the soil is in condition and must be prepared for a crop. If the soil has become dry and hard it is necessary to throw up levees and preirrigate the field. Then when it has dried sufficiently the plowing proceeds.

No soil should be plowed or worked if it is not in proper condition. This may be judged by picking up a handful and squeezing it. The ball should hold its shape yet crumble easily when touched. It must not be sticky or smeary. Plowing of any but the sandy soils when they are too wet is to endanger an upset in their structure which will result in the formation of many lumps. These will work up with difficulty and may require several seasons of culture to overcome. Moreover the compaction of the wet soil by the plow share can lead to the formation of a plow sole or plowpan.

Compaction is also caused by the use of trucks and heavy equipment when the soil is too wet or too dry. Chiseling to shatter and break up the compacted layer is necessary if water and roots are to penetrate properly into the lower depths of the soil mass.

Fall plowing is practised to get that much of the work done when other work is not so pressing. The roughness of the furrows is an aid in preventing erosion if they run with the contour of the land and if these ridges are thrown up fairly well the soil dries more quickly in spring. The freezing and thawing action is very beneficial on heavy soils although a large number of alternate freezing and thawing periods may actually deflocculate these soils. Crop residues and other organic materials which are turned under begin to decompose and are therefore more useful to the spring crop when it is planted. If any considerable amount of green vegetable matter or sod is plowed under in the spring, especially late in the spring, it may reduce the nitrate supply to the cash crop as the bacteria decompose it. Late fall plowing brings to the surface insects in their winter stage and thus they may be destroyed by

freezing. Fall plowing permits earlier use in the spring for with some soils and with shallow-rooted crops a thorough disking is sufficient spring preparation. In the South, fall plowing may permit too much leaching if no cover crop is sown.

Spring-plowed land may contain less moisture than that plowed in the fall, since the operation necessarily loosens the soil to the plow depth and permits much moisture to escape. Timeliness is essential in preparation for spring plantings. If plowing is not done and the land fitted as soon as dry enough, several weeks of inclement weather may set in and the early market be lost.

Shallow soils may be gradually deepened by plowing to slightly greater depths each succeeding year. Thus small amounts of subsoil are mixed in with the productive top-soil without injurious results to the crop. A 7 to 8-inch top-soil is satisfactory for most crops. As the depth of fertile soil is increased and the organic matter content augmented the feeding area and moisture supply for the roots are increased.

Plowing Tools.—Besides the walking and riding plows various types of tractor-drawn plows are used by vegetable growers. These vary from the small tool on the garden tractor to the 10 or 12-inch plow used on the lighter riding tractor and then to the multiple bottom outfit of the large farm tractors. When the soil is hard or dry, disk plows are preferred to bottom plows. These may be 20 to 30 inches in diameter. Equipment with rotating tines or blades which tear up and pulverize the soil can be used in place of bottom or disk plows to prepare the seed bed in one operation. Chisels which loosen the soil to a depth of 18 inches or so are useful in breaking up a hard pan, clay pan, or compacted layer that may have been developed by poor soil-handling practicies. They will not serve where vegetable matter or plant residues must be turned under.

Harrowing.—In spring and summer this operation should follow as closely after plowing as practicable. In general it is best to plow no more land than can be harrowed the same day, so as to break up the lumps before they have a chance to bake and harden. As with plowing the proper degree of soil moisture is a prerequisite to an efficient job. The harrow should be run first with the furrows and then across them. Fall-plowed land is usually left in the rough. Harrowing would increase surface run-off and might cause heavy textured soil particles to run together. Overharrowing is to be avoided as it destroys the structure of the soil which has been developed by plowing or disking.

The leveling of the surface by the harrow fines the upper layers of soil. If the area is not to be planted soon it should be harrowed from time to time to kill the small weeds which continue to appear.

This fallowing and harrowing a piece of land through the hot days of summer controls quack grass.

A number of types of harrows are in use. The *disk or cutaway disk* cuts and pulverizes the soil to a good depth and therefore is an indispensable tool, especially for cutting up plowed sod and working heavier soils. It does not do a finished job and is, therefore, followed by a *spring tooth, spike tooth* or *Acme harrow.* These types are as their name would indicate. The Acme has a series of parallel cutting blades which fine and smooth in one operation. The spring tooth, but not the spike tooth, will also break up lumps. It is better than either the spike or Acme on stony ground. The preparation furnished by these harrows is satisfactory for setting out plants but when seeding is to be done additional treatment is essential. This can be accomplished with a *pulverizing* and *smoothing* harrow consisting of many closely-spaced small disks with an adjustable levelling board across the frame.

Cultipackers, rollers of various types or *plank drags* will break up the clods and lumps, pack the loose soil and smooth the surface. They are very useful on light soils and peats.

The order of fitting operations following plowing varies with the time of season, the class of soil, its condition and the contemplated use of the land.

Synthetic Soil Conditioners.—Complex organic compounds have become available that will maintain good soil structure for several years provided the soil is in good physical condition at the time they are applied. It takes 1000 pounds or more to the acre so the cost is almost prohibitive except on small garden plots. The best procedure is to spread the conditioner over the surface and mix it thoroughly with the soil. These materials will not take the place of organic matter in the development of a productive soil.

Making Beds.—Where furrow irrigation is practiced there is an additional operation not common to other areas. That is the making of beds. These are thrown up by *listers, double mold-board plows* or *middlebusters.* Three of these will form two beds and the halves of two others. These rough beds are later smoothed or shaped either before or in the operation of planting. They are made on 24 to 42 inch centers.

Soilless Culture.—Growing plants without soil is not a new development but merely the extension of the techniques employed for over seventy-five years by plant physiologists in studies of nutrition. The nutrients are supplied in solution to plants, the roots of which are in sand, gravel, cinders, or in a tank of the solution itself. Some plants require more aëration for root activity than do others. This is obtained by putting the solution on the surface and allowing it to drain through, raising and lowering the level

of the solution by means of a pumping system, or else by bubbling air through the water culture if no inert material is used for the plant bed.

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Chapter 9

MAINTAINING SOIL ORGANIC MATTER

THE organic or vegetable matter in the process of decay in the soil plays an important part in crop production. The practice of supplementing soil organic matter by plowing down crop residues and animal manures has been known for a long time to be of utmost importance as a means of maintaining the life of a productive soil. When land is tilled frequently, as is the case in vegetable production, the content of organic matter may be depleted rapidly. This is due to the stimulation of bacterial activity through better aëration. As the soil water passes through it dissolves out some of the organic matter. Thus the various oxidation processes are constantly reducing the supplies of organic material in the soil, but they are being renewed by the decomposition of the bodies of soil organisms, old root systems, or any top growth and added material which may be plowed into the soil.

The so-called soil humus is a complex organic substance. In general, the term is used to mean organic material in an advanced state of decay.

The quantity of organic matter varies with the class of soil and its treatment, but averages between 1 and 3 per cent. It is difficult and costly to attempt to increase the organic matter content of a soil above the normal level for the prevailing soil and climatic conditions. In order to be functional the organic matter must be undergoing decomposition not just accumulating. If the fertility of the soil is to be maintained, new supplies of organic material must be added constantly. As it decomposes it serves several purposes.

1. The physical structure of the soil is improved by the cementing of particles into aggregates.
2. The ease of water penetration is facilitated.
3. Aëration is improved.
4. The crusting of the soil over young seedlings is reduced.
5. Soil microörganisms use it as a source of energy.
6. Organic acids formed in its decomposition may make soil nutrients available.
7. The carbon dioxide evolved may increase photosynthesis as it arises above the soil surface.

8. Organic matter might serve as a source of certain plant hormones and anti-biotic substances.

9. The decomposing organic matter and the base-exchange properties of the final humus can be important in the retention and release of plant nutrients to the crop plants.

The soil microörganisms utilizing the organic matter produce certain polysaccharides that are the substances effective in forming the aggregates of soil particles.

Crop residues in themselves are not sufficient to furnish this important material, and the need for making a definite provision in the cropping scheme for the incorporation of humus-forming materials is becoming better appreciated.

There are three classes of materials available to the gardener for maintaining the organic content of the soil. These are animal manure, artificial manure, and crops which are grown specifically for turning under in a green state, or otherwise known as green manures. Manure makes soils less acid but green manures have little effect on the soil reaction.

ANIMAL MANURES.

The excrement of animals constituted one of the earliest fertilizing materials, having been mentioned by early Roman and Chinese writers as being of value. In the days when livery stables flourished in all large cities, nearby market gardeners could obtain almost unlimited supplies for the mere cost of hauling. Such is no longer the case, and to make up in part for this deficiency stock-yard manure is shipped considerable distances.

Animal manures are usually available for the farm garden. Their function as carriers of nitrogen, phosphoric acid and potash will depend on the kind of manure, the amount of bedding used under the animals and the care given the manure before it is added to the soil. The proportion of the common fertilizing elements in different sorts of manure is shown in Table 7.

Analytical studies indicate that the urine is much richer in nitrogen and potash than the solid matter. Adequate bedding to absorb this liquid will materially increase the value of the manure. Probably one-half of the fertilizing value of the animal's total excrement is contained in this liquid.

While manure contains a considerable percentage of fertilizing elements, these usually can be purchased more cheaply in the form of commercial fertilizers. For example, 1 ton of horse manure contains about 10 pounds each of nitrogen and potash, and 5 pounds of phosphoric acid. These 25 pounds could be purchased in mineral form for $2.50 yet the cost of the ton of manure

TABLE 7.—APPROXIMATE AVERAGE COMPOSITION OF MANURES (FRESH) FROM VARIOUS ANIMALS (CANADIAN DEPARTMENT OF AGRICULTURE BULLETIN 92. NEW SERIES, 1927).

Kind of animal.	Relative proportions of solid excrement, liquid excrement and bedding in manure.	Pounds per ton.	Nitrogen.		Phosphoric acid.		Potash.	
			Per cent.	Pounds.	Per cent.	Pounds.	Per cent.	Pounds.
Horse	Solid excreta	1,200	0.55	6.60	0.30	3.60	0.40	4.80
	Liquid excreta (urine)	300	1.35	4.05	Trace		1.25	3.75
	Bedding material	500	0.50	2.50	0.15	0.75	0.60	3.00
	Total mixture	2,000	0.66	13.15	0.22	4.35	0.58	11.55
Cow	Solid excreta	1,260	0.40	5.04	0.20	2.52	0.10	1.26
	Liquid excreta (urine)	540	1.00	5.40	Trace		1.35	7.29
	Bedding material	200	0.50	1.00	0.15	0.30	0.60	1.20
	Total mixture	2,000	0.57	11.44	0.14	2.82	0.49	9.75
Pig	Solid excreta	990	0.55	5.44	0.50	4.95	0.40	3.96
	Liquid excreta (urine)	660	0.60	3.96	0.10	0.66	0.45	2.97
	Bedding material	350	0.50	1.75	0.15	0.42	0.60	2.10
	Total mixture	2,000	0.56	11.15	0.30	6.03	0.45	9.03
Sheep	Solid excreta	1,206	0.75	9.04	0.50	6.03	0.45	5.43
	Liquid excreta (urine)	594	1.35	8.02	0.05	0.30	2.10	12.47
	Bedding material	200	0.50	1.00	0.15	0.30	0.60	1.20
	Total mixture	2,000	0.90	18.06	0.33	6.63	0.95	19.10
Poultry	Solid excreta	1,900	1.00	19.00	0.80	15.20	0.40	7.60
	Bedding material	100	0.50	0.50	0.15	0.15	0.60	0.60
	Total mixture	2,000	0.97	19.50	0.77	15.35	0.41	8.20

may be twice that. Moreover, we are assuming that the nutrients in the manure are as available as in mineral form, which is far from true.

The care of the manure obviously affects its content of fertilizing elements. If it ferments in a heap ammonia may be lost into the air, and unless the stack sheds the rain well or is under cover, the resultant leaching will carry off much of the soluble materials. Frequently half the value of the manure is lost during the process of decomposition.

When the land is occupied with growing crops it is inconvenient to spread the fresh manure from the stables on the land. Even if applied among the plants as a mulch the ammonia fumes which arise from fresh manure might burn the foliage. It is usually most satisfactory to spread the manure directly from the stables during the winter. Thus practically the full value can be added to the land, and unless the slope is too great little loss from washing will result. Broadcasting of manure may be done in preparation for a planting as long as there is sufficient time for it to become well decomposed.

Well-rotted manure is more popular than fresh manure with many growers. Most of the weed seeds will have been killed in well-rotted manure. While rotted manure works into the soil easily, a strawy manure is more effective in opening up a heavy soil. On the basis of equal weight rotted manure has a somewhat greater content and degree of availability of the mineral elements contained than is the case with fresh manure. It can be used as a mulch around growing plants with no danger of burning from ammonia fumes. Rotted horse or barnyard manure, and the fresh manure of sheep and hens may be harrowed in after plowing but other fresh manures containing considerable litter are difficult to incorporate in the soil unless they are plowed under.

As indicated previously the microörganisms in the soil attack any carbohydrate material placed therein and use it as a source of energy for their growth and multiplication. Some 60 or more per cent of the dry weight of bacteria is protein in nature, and this contains about 16 per cent of nitrogen. When organic matter is added to the soil the increased activity of microörganisms must consume necessarily considerable amounts of the nitrate nitrogen which is being formed by the process of nitrification through the activity of the nitrifying bacteria. In fact the nitrate supply may be entirely depleted. It is not lost but will reappear when the proteins of the bacteria are disintegrated. Plants growing in the soil at the same time would be starving for nitrogen. This means that very strawy manure must be incorporated sufficiently ahead of planting for the decomposition to be well under way and the

content of nitrates being built up once more. This may require two, three or more weeks according to the weather, but may be hastened by the addition of adequate supplies of readily available nitrogen. Organic matter containing waxes, resin, fats and tannins is slow to decompose. This may be often the objection to using manure from animals bedded with shavings or sawdust, especially of pine or related woods, although experiments in Rhode Island showed about the same yields of vegetables over a six-year period with manure, whether straw or planer shavings and sawdust were used for bedding.

The preparation of artificial manure is simply a matter of producing in a pile of straw or other plant materials the decomposition process that normally occurs under ground.

Quantities of Manure to Apply.—The intensive vegetable grower has looked hopefully to the manure economy experiments to solve his problem. Manure supplies are short and usually he feels that he cannot spare his high-priced land long enough to grow a sod. In such a situation moderate applications of manure plus a complete fertilizer will work well. One can use 4 to 5 tons of poultry manure or 10 to 15 tons of stable manure to the acre with about half as much mineral fertilizer as would be applied without the manure. This commercial fertilizer should be high in phosphoric acid to balance the low quantity of this nutrient supplied by the manure, or 20 per cent superphosphate may be spread with the manure at the rate of 30 to 50 pounds per ton to accomplish this end.

It has been possible to omit entirely the manure and by turning under a good growth of green manure get as good yields with this and fertilizer as with manure and fertilizer.

GREEN MANURES.

The maintenance of a proper supply of organic matter is not much of a problem for the trucker or the producer of canning crops, since they can plan to put their land down in sod at sometime in their rotation. However, the more intensive gardener is finding that he must seed his land to some sort of crop suitable for plowing under whenever his land is unoccupied by a cash crop. Any growing plant which is plowed under instead of being harvested is known as a soil improving crop or *green manure*. It is a practice of very ancient origin, having been well known to the Chinese, Greeks and Romans long before the birth of Christ. Crop yields can be maintained by substituting or supplementing animal manures with green manures if additional mineral fertilizers are used. In the South the vegetable grower crops his land

through the winter months to supply the more northerly markets. He can use the summer months to build up the organic matter with a soil-improving crop. In other sections where rain or snow prevent winter vegetable production, a soil-improving crop should be planted as a *cover* crop.

A green manure as a cover crop prevents erosion. It also conserves nitrates in fall and early spring since any which may be produced can be taken up by the roots and thus are not lost by leaching or erosion. If it is one of the legumes it may add nitrogen by bacterial action in the root nodules. This may amount to as much as 100 pounds or more of nitrogen an acre. The roots may penetrate the subsoil and by loosening it permit the succeeding crops to penetrate the lower layers and draw on the water supplies of these regions. The roots may take up limited quantities of minerals in the subsoil, which are returned later to the top soil. In addition to these effects, green manures serve as do animal manures, in adding organic matter, aiding bacterial growth and may increase the solubility of some of the minerals in the soil through the action of the acids formed in their decomposition. It should be possible by careful planning to grow a green-manure crop on all land at some time every year. It may be seeded at the last cultivation, or following a crop removed in late summer, and plowed under late in the fall when an early spring vegetable is to be planted. Late fall planting with spring plowing will be suitable for rye prior to a crop planted late the next spring.

Crops to Use.—Rapid production of material is essential since time is usually short. Climatic and soil adaptation, type of root growth and the ease with which the top growth may be worked into the soil are other factors influencing the selection of the green-manure crop. When our knowledge is more complete on the effect of one crop on another we may find that certain green-manure crops may exert a particularly good effect on the growth of some specific vegetable crop. Although it does not harbor in its roots the nitrogen-fixing bacteria, Rosen rye sown at the rate of 2 bushels per acre is one of the most popular green-manure crops with vegetable growers, especially in the North. Its wide adaptation, hardiness and possibility of late fall seeding recommend it for use as a winter cover. The Abruzzi rye is preferred in the South. Buckwheat, millet, oats, barley, Sudan grass, rye grass and wheat are other non-legumes used.

It is easily seen that the use of a legume as a green-manure is desirable whenever conditions will permit, although not all legumes are more efficient than non-legumes in maintaining a high content of nitrate nitrogen through the main part of the season after being plowed under.

There is evidence that the organic matter left in the soil by various soil-improving crops and even by the vegetables themselves has a differential effect in modifying the soil microflora. Some residues will favor the development of detrimental organisms. Those from other crops might stimulate beneficial organisms that could have an antagonistic effect on the detrimental ones thus improving the soil for crop growth.

TABLE 8.—APPROXIMATE ANNUAL REMOVAL OF NITROGEN AN ACRE THROUGH CROPPING AND LEACHING, WITH THE APPROXIMATE AMOUNTS CONSERVED BY VARIOUS GREEN MANURES. (ADAPTED FROM J. W. WHITE, PENNSYLVANIA STATE COLLEGE.)

Crops.	Yield in tons an acre.	Pounds of nitrogen removed by crop.	Total poundsof nitrogen removed.[1]	Equivalent to pounds of 5-10-5 fertilizer.
Early lettuce	5	23	67	1340
followed by late cauliflower	3	24		
Early carrots	7½	29	119	2380
followed by late cabbage .	10	70		
Early beets	5	26	99	1980
followed by kale . . .	7	53		

Green manure.	Green weight of tops an acre.	Pounds organic matter furnished in tops and roots.	Pounds nitrogen conserved in tops and roots.	Equivalent to pounds of: Nitrate of soda.	5-10-5 fertilizer.
Wheat	6 tons	5,928	100	650	2000
Rye	6 tons	4,704	78	507	1560
Buckwheat	6 tons	3,960	89	579	1780
Sweet clover . . .	6 tons	5,352	138	897	2760
Sweet clover . . .	12 tons	11,520[2]	229	1489	4580
Rye or wheat 5 in. high	3315 lbs.	1,200	40	260	800
Oats 8 in. high . .	5308 lbs.	1,050	61	397	1220

[1] Including an estimated annual loss of 20 pounds by leaching.
[2] Equivalent to about 27 tons of manure.

Many leguminous crops are adapted for use as green manures. In the North the annual and biennial white sweet clovers, soybeans, Canada field pea, and red and mammoth clovers are used for summer growth. Hairy vetch will do for winter, usually planted with rye. For the South summer possibilities are crotalaria, soybean, cowpea, velvet bean, lespedeza, yellow and white sweet clover, beggarweed, and guar. In the winter Austrian pea, purple

and hairy vetch, bur and crimson clover and Melilotus indica (bitter clover) can be used. Intermediate areas will find useful some of the green manures of the South.

Fertilizing the Green-manure Crop.—The fertilizer residues left by the previous cultivated vegetable will be used by the green-manure crop. Often growth will be aided by the application of 60 pounds each of phosphoric acid and potash. Additions of available nitrogen may be beneficial to the non-legume green manure. The use of a little stable manure just before plowing under the green manure may give beneficial results more than proportional to its content of fertilizing elements. The effect may be due to the large number of bacteria thus added to the soil. Obviously it is worth while to use whatever fertilizer application appears necessary in order to obtain a heavy growth of the green-manure crop, since these nutrients will become available to the succeeding vegetable crop.

Part of the nitrogen that would have been given later to the cash crop can be put on the green-manure crop and thus serve a double purpose. It will help stimulate the development of the soil-improving crop and still be present in the soil for the vegetable that follows.

Time of Plowing Under the Green-manure Crop.—If there is a heavy growth to be turned under it may be desirable to cut it twice with a disk before the land is plowed; the second time over to be at right angles to the first. A chain on the plow will often help to get the tops well under.

The furrow slice should be laid at an angle of about 30 to 40 degrees. This will give better granulation of the soil than if the green material is placed in the bottom of the furrow. Heat and moisture are necessary for a rapid decay of the green manure. Careful compacting with a roller will aid moisture conditions and consequently decomposition.

Other soil factors which increase the rate of breakdown are aëration, the initial population of soil organisms and the supply of minerals, especially nitrogen and lime. All of these operate obviously through their beneficial influence on the growth and number of microflora.

Another factor concerned in the process is the green-manure crop itself. Leguminous crops containing considerable nitrogen will decay more quickly than the non-legumes. The nitrogen-carbon ratio in the young green-manure crop is narrower than when maturity is approached. The wider the ratio the less readily will be the material decay. The narrowing of the ratio is one benefit obtained by fertilizing the green-manure crop with nitrogen as it is growing.

Whether the green manure should be turned under in the

fall, early or late spring will depend upon the crop to follow. In general the grower is seeking an increased humus supply and will allow the green manure to grow as long as possible, provided it will be mixed with the soil and the decay well started before the cash crop is planted. The later in the season the green-manure crop grows, the more it will dry out the soil and the more resistant to decay it will become. It must decompose in order to be of benefit. As in the case of very strawy manure, additional nitrogen at the rate of 50 to 100 pounds per acre or about 25 pounds per ton of dry matter in the form of nitrate of soda, cyanamid or some other carrier applied previous to plowing will facilitate the rotting of the green-manure crop and counteract nitrate depletion. Normally in the soil itself the nitrogen-carbon ratio is about 1 to 10. When it is vastly widened to 1 to 30 or 1 to 60 by the incorporation of a soil-improving crop the necessity for this additional nitrogen is obvious.

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Chapter 10

FERTILIZING THE CROP

MANURE is costly, slow to give up the nutrients needed, and being low in phosphorus is an unbalanced fertilizer. Thus it is not a desirable means of fertilizing a quick-growing crop, especially in the spring. The so-called commercial fertilizing materials are usually more available, cheaper, and may supply single elements or be complete even to the rarer elements needed in minute quantities. Such fertilizers may be mixed according to the type of soil and crop. They may contain one or more forms of the same element—for example, nitrogen in tankage and sodium nitrate. There are three primary nutrients that are utilized by vegetable plants in large quantities. These are nitrogen, phosphorus and potassium.

Nitrogen.—Nitrogen is the most expensive of the essential elements, but with the development of the establishments manufacturing it synthetically this cost has been reduced. Although nitrogen is made available to plants by the nitrifying action of microorganisms, this process is hindered by cool wet weather. Thus applications of readily available nitrogen are necessary under such conditions to produce vigorous vegetative growth. This element forms part of the chlorophyll molecule and is combined also to form proteins.

The mineral forms in use which supply nitrogen are nitrate of soda (16 per cent N)[1], sulphate of ammonia (20.5 per cent N), calcium nitrate (15.5 per cent N with some lime) and cyanamid (21 per cent N with some lime). Sulphate of ammonia has been found to lose its nitrogen by leaching in a sandy loam soil only about one-third as rapidly as is the case with nitrate of soda. Ammonium sulphate increases the acidity of the soil while nitrate of soda has a slight alkaline effect.

Calcium-ammonium nitrate (Cal-Nitro) contains 20.5 per cent nitrogen—one-half as nitrate—one-half as ammonia—with some lime. Urea is produced synthetically, and carries 46.5 per cent of nitrogen in the amid form which is readily available. NuGreen, a prepared urea, supplies 45 per cent nitrogen. Ammonium nitrate has 33 to 35 per cent nitrogen, one-half in the ammonia form and the other in the

[1] Approximate analysis of commercial materials.

nitrate. Anhydrous ammonia, which is a dry gas compressed into liquid form, supplies 82 per cent nitrogen. It is used extensively for injection into the soil or introduction into the irrigation water. Aqua ammonia, which is ammonia gas dissolved in water, carries about 20 per cent N. It is used similarly to anhydrous ammonia. Other nitrogen solutions are coming into general use for non-pressure or low pressure application. These contain from 20 to 41 per cent nitrogen depending on the particular combination of ammonia, ammonium nitrate, urea or other nitrogen carrier used in their preparation.

Urea and NuGreen are synthetic organics. The natural organics such as animal tankage (5 to 10 per cent N and 3 to 13 per cent P_2O_5), cottonseed meal (6 to 9 per cent N, 2 to 3 per cent P_2O_5 and 1 to 2 per cent K_2O), dried blood (9 to 14 per cent N) and various fish products (5 to 10 per cent N and 4 to 8 per cent P_2O_5) are costly. These natural organics are less readily available to the plants than are other sources of nitrogen.

Phosphorus.—Phosphorus is the cheapest of the more important elements and gives responses in growth from applications far in excess of the amount that an analysis of plant ash for this element would appear to justify. Nearly all soils are low in readily available phosphorus and this is usually a limiting factor. When phosphoric fertilizers are mixed thoroughly with the soil, much of the phosphorus is fixed or becomes unavailable to the plant due to the formation of insoluble calcium phosphates in soil rich in lime, or iron and aluminum phosphates in very acid soils. Thus, the need for large phosphorus applications on some soils. Earlier maturity in a number of vegetable crops, especially cabbage, sweet corn, tomato and lettuce, has been correlated with the presence of adequate supplies of soluble phosphorus. When crops are growing in soils colder than about 55 to 60° F. it is important to have available phosphoric acid placed close to the roots.

It is a common practice to add 50 pounds of superphosphate to 1 ton of manure to make a more nearly balanced fertilizer. Superphosphate (16 to 20 per cent phosphoric acid) is better than raw rock phosphate as the tricalcium phosphate has been changed to a more soluble form by the use of sulphuric acid. Bone-meal contains from 3 to 4 per cent N and 20 to 25 per cent P_2O_5 but the latter is not immediately available. Superphosphate has no effect on the soil reaction. Rock phosphate has a slight alkaline effect while bone-meal leaves considerable residual alkalinity. Double, treble, or triple superphosphate carrying 40 to 50 per cent available phosphoric acid is used for direct application to soil as well as in the making of concentrated fertilizers. Ammonium phosphate-sulphate has 16 per cent N and 20 per cent P_2O_5. There

is another synthetic product, ammonium phosphate, with 11 per cent N and 48 per cent P_2O_5. Both of these compounds increase the soil acidity. Liquid phosphoric acid (52 to 54 per cent P_2O_5) can be injected into the soil or supplied in the irrigation water. It has an acidifying action.

Potassium.—Potassium is of medium cost. This element is associated with the production of carbohydrates in plant tissue and is believed to increase resistance to disease. The muriate (50 to 60 per cent potash) or sulphate (48 to 52 per cent K_2O) forms have been used most commonly. Potassium nitrate (12.3 per cent N and 44 per cent K_2O) is a manufactured product.

The cost of wood ashes (5.5 per cent K_2O) is usually too high in proportion to their value. Other forms of potash are kainit (20 per cent K_2O) and the so-called manure salts (30 per cent K_2O).

Secondary Nutrients.—Besides nitrogen, phosphorus and potassium there are other elements that are also essential for plant growth. Since these are utilized in small quantities or sometimes in traces only they have been termed secondary, minor, micro or trace elements. Calcium, sulphur and magnesium are used by plants in greater quantities than are iron, copper, manganese, boron, zinc, and molybdenum. The first three of these secondary elements are furnished indirectly in the fertilizer chemicals or in soil amendments. Special provision may have to be made on some soils to supply one or more of the last six.

The prevalence of deficiencies of secondary elements is probably due to the low natural content of these in certain soils, the decreased use of animal manures, the intensive cultivation of the land with resultant loss through leaching or crop use, the utilization in fertilizers of synthetic chemicals containing few impurities, and to an increased knowledge of deficiency symptoms.

A deficiency of iron is most likely to be found in calcareous soils; of manganese in naturally alkaline or over-limed soil; of copper on soils containing a great content of organic matter; and of molybdenum in very acid soils. Boron and zinc deficiency have occurred in a wide range of soil types and conditions. Where definite deficiencies of any of these secondary nutrients exist special applications to the soil or foliage must be made.

Sodium has been shown to be important as a substitute for part of the potassium requirement of a number of vegetables. Certain crops, notably celery, beet and turnip, have given a response to sodium applications even where the potassium supply in the soil would be considered adequate. Thus sodium seems to have a value of its own in crop nutrition. Nitrate of soda supplies the sodium when it is the source of nitrogen. Several state colleges recommend

the application of common salt-sodium chloride-for beets. On the other hand many soils in the West have almost a toxic level of sodium.

Various organic compounds (chelates) containing secondary nutrients appear to hold promise as materials for use in overcoming deficiencies.

COMPLETE FERTILIZERS.

Ready-mixed goods may be purchased or the component materials obtained and home mixed. State laws are often such that the publicity attendant upon the sale of materials that are less than their guaranteed analysis insures the buyer proper value as to quantity of the contained elements. Some states require that the tag attached to the fertilizer bag show the guaranteed content of the secondary nutrients as well as that of the primary ones.

Grade or *Analysis* means the percentage of nitrogen, phosphoric acid and potash in the fertilizer, while *ratio* means these percentages reduced to their lowest common denominator. The *formula* is the recipe showing the pounds of the various ingredients mixed together to make a ton.

High-analysis fertilizers are those which contain 20 or more per cent of the plant nutrients. An analysis of 5 per cent nitrogen, 10 per cent phosphoric acid, and 5 per cent potash or 5:10:5 indictates a fertilizer of this type. A concentrated fertilizer is one containing 30 or more per cent of plant nutrients. The overhead cost of mixing, bagging, shipping, hauling and spreading a ton of low analysis fertilizer is just as great as for one containing more of the valuable elements.

In preparing the formula the quantities of the various ingredients are selected that will give a total approaching 2000 pounds of the desired analysis. The balance of the ton is made up with some conditioner and maybe with some dolomitic limestone. Animal and vegetable by-products make good conditioners and furnish some nutrients. Garbage tankage is a poor source of nitrogen but serves well to keep the fertilizer in good mechanical condition for drilling.

New manufacturing techniques have stimulated a definite trend toward the production of granular fertilizers. These are non-caking and free flowing.

Most mixtures have an acidifying effect on the soil, but by the the proper choice of materials and the addition of dolomitic limestone in the formula, a so-called neutral or non-acid forming mixture is obtained.

In mixed fertilizers the ratio is the important consideration from the point of view of the crop and the analysis may be quite high if some of the more concentrated carriers are used. The

15:30:15 analysis could be used in place of a 5:10:5 or 10:20:10, by applying considerably less total weight to an acre, since all are in a 1:2:1 ratio. Obviously economy and assurance of good quality lie with the high-grade goods. Concentrated fertilizers when properly applied are less likely to cause injury to plants than are mixtures of lower analysis if the same quantity of plant nutrients per acre is supplied in each. This is owing to a lower content of soluble material other than nitrogen, phosphoric acid, and potash in the concentrated fertilizers as compared to that in less concentrated mixtures.

Pricing of fertilizer materials is usually done on a *unit* basis. A unit of plant food is 20 pounds or 1 per cent of a ton. Thus the number of units of nitrogen in a ton of nitrate of soda is 16, and in a ton of a 5:10:10 analysis it is 5.

Liquid fertilizers are available in many analyses. These can be used as starter solutions in transplanting, can be applied in irrigation water, dropped with the seed, or put in the soil as a side-dressing during cultivation. In each case the material as purchased is diluted. Manufacturer's directions should be followed.

Home Mixing.—Home mixing is justified when a considerable tonnage of fertilizer is needed, or when a special ratio is desired for a particular crop. Straight chemicals may be purchased and mixed at a saving of approximately $5 to $10 a ton. Care must be exercised in mixing the components since those which contain lime may release ammonia from the nitrogen carriers, or cause the stack to harden. If compounded just before applying to the soil this need not be a special consideration. Shoveling the pile over three or four times will usually mix the various ingredients sufficiently. A concrete mixer is helpful.

QUANTITY OF FERTILIZER TO USE.

The quantity of fertilizer which must be supplied depends upon the character of the soil, and its previous treatment in respect to cropping and fertilizing, the type of rotation which is followed, the success of the previous crop and the particular vegetable to be grown. Adequate supplies of organic matter, proper soil reaction, thorough preparation of the land and good drainage are all necessary.

There is a rather common idea that a chemical analysis of a sample of soil, or of the ash constituents of the plant, will indicate exactly what fertilizing materials should be added. A consideration of the influences just mentioned and the fact that the weather during the future season of growth will affect the activity of microörganisms in their relation to mineral availability make

apparent the fallacy of such a supposition. The so-called quick tests of soil which eliminate a tedious chemical analysis have been popularized as a method of determining fertilizer needs. Similar plant tests have also been devised. These methods do have some diagnostic value but repeated trials on soils of which the response to fertilizer is known have indicated limitations in their adaptability. A skilled worker taking into consideration the results of the quick tests together with the known history of the land, might estimate the analysis and quantity of fertilizer required.

The law of diminishing returns is a reasonably safe guide to govern fertilization for vegetable growing. Increasing quantities of fertilizers may be given, if other necessary factors have been considered, as long as the crop returns a profit over the cost of the larger application. Enough for a maximum yield but not an overdose should be the rule. Light applications may be of little benefit to the crop because all that is added is fixed by the soil.

In the spring greater applications of mineral fertilizers are advisable than later in the summer because these elements are made available but slowly until the microflora of the soil becomes exceedingly active.

Crops grown on soils which have been cropped for a long time, especially in areas subject to heavy rainfall, are likely to need nitrogen, phosphoric acid and potash. Vegetables produced on the more virgin soils of the semi-arid West generally respond to nitrogen and sometimes to phosphoric acid also.

Muck soils should receive less nitrogen and more potash than mineral soils. Mucks used for several years need more nitrogen than newly-cleared mucks. Sandy soils should receive more nitrogen than other mineral soils. Phosphoric acid tends to accumulate in a soil which has been liberally treated with a complete fertilizer for a long period. Crops on such soils are likely to respond better to a 1:1:1 than to a 1:2:1, 1:3:1 or 1:4:1 ratio. Where no manure is applied nor a good soil-improving crop turned under it is desirable that a 1:2:1 ratio be used with a 30 to 50 per cent heavier application than would otherwise be the case.

The crop will determine to a considerable extent the quantity of fertilizer which can be profitably added. One which will give a large cash return justifies a heavy application of fertilizer. But a mere statement of the rate of application is not adequate in view of the number of possible ratios and analyses. Both rate and analysis must be considered. In fact, it is desirable to make recommendations in terms of the pounds of nitrogen, phosphoric acid and potash from which a response may be expected by a given crop. An analysis and rate of application may then be selected which will supply approximately this quantity of the three primary fertilizer nutrients.

The grower should bear in mind that the soil is really the matrix with which he works. He puts in the fertilizing materials. Some are lost, some fixed by the soil, some taken up by the crop and some residues remain for succeeding crops. But since good gardening calls for the constant up-building of the soil, he will not stint in his fertilizer applications. In the home garden, for an assortment of vegetables, a 5:10:5, 5:10:10 or 10:10:10 analysis broadcast at the rate of 5 pounds to each 100 square feet is satisfactory.

METHOD OF APPLICATION OF FERTILIZER.

Fertilizers may be applied broadcast over the whole area, in bands or as a top dressing about or beside the growing plants. The particular method which may be used will depend upon climatic conditions, the kind of crop, the class of soil, the quantity and kind of fertilizer to be added as well as the purpose it is expected to fulfil. A region in which moderate temperatures and rather favorable moisture conditions prevail would present a different problem from one more subject to drought and hot winds. Stimulation of early growth might call for closer placing of fertilizer and seed than if increased yield alone were the aim.

Since phosphorus and to some extent potassium are fixed by the soil in thorough mixing, band applications serve to reduce fixation and maintain the fertilizer in a form available to the plants. But should the band of fertilizer be above, below or at the side of the seed or plant? In the light of present knowledge it is safer to place it level with or slightly below and about 2 to 4 inches on each side of the seeds or the roots of transplanted plants. It should never be in direct contact with them as the death of the seeds, roots or seedlings may result from plasmolysis (withdrawal of water)—popularly called "burning." Band applications may not be conducive to maximum yields with some crops.

In vegetable production the desired rapid early growth can be stimulated best if the fertilizer is relatively near the young plant as with band applications. Although the fertilizer is localized and may increase root branching at that point it will not cause a restriction in root development. Studies of root development seem to show that as crops reach maturity their ramified root systems draw on the deeper layers of soil for water and mineral elements. When 500 pounds or less of fertilizer are to be applied to an acre, especially in rather widely spaced crops, or on soils of a low fertility level, this method should be followed. When large quantities are used part of the fertilizer may be broadcast and the rest applied in bands, or some used in bands to stimulate early growth and the rest placed well down in the plowed depth to the sides of

the rows before the roots enter that area. Fertilizer attachments may be purchased for seeders and planters which will distribute this material in bands Attachments can be put on the plow which will distribute the fertilizer in a band at the bottom of the furrow where it will most likely be in moist soil and available to the roots.

When fertilizer is spread over the whole area, this operation may precede plowing which will then mix the fertilizer throughout the zone of root development. Fertilizer broadcast after the land is plowed and leveled is harrowed into the surface as deeply as possible. Lime spreaders or grain drills will give satisfactory distribution.

It is possible to get delivery of fertilizer from the factory by a truck which will broadcast it directly onto the land. This saves the grower having to make an investment in some type of spreading machinery. The danger is that heavy trucks broadcasting the fertilizer on plowed land, especially if it is moist, may cause considerable soil compaction.

Anhydrous ammonia, liquid phosphoric acid, and the various nitrogen solutions are best injected into the soil ahead of planting. Special equipment is required. It is important that the anhydrous ammonia, which is released as a gas under high pressure, be put at least 4 inches deep in the soil and covered in the same operation in order to avoid loss into the atmosphere. The liquid phosphoric acid and the nitrogen solutions can be placed at about the same depth. All these materials are as equally available to the plants as are the dry forms.

Soluble and liquid fertilizers, except those containing free ammonia, are readily injected into the sprinkler irrigation lines for distribution with the water. After such use clear water should be applied for a half hour to rinse out the pipes and free the foliage of the chemicals.

Side dressing with a soluble nitrogenous salt is often a necessary practice to obtain rapid continuous development in cool wet weather. The materials should not be placed on or against the plants as "burning" will result. Continued use of excessive quantities of nitrate of soda may destroy the physical condition of the soil and cause deflocculation of the soil particles. Several good machines are on the market which dress one or two rows and in varying amounts. The usual top-dressing application is of 15 to 30 pounds of actual nitrogen an acre, which is equivalent to 100 to 200 pounds of nitrate of soda. Where furrow irrigation is practiced the side-dressing can be accomplished by introducing some form of nitrogen into the irrigation water at the pump outlet or at the head ditch.

Minor elements can be supplied by foliar sprays but too much of the primary nutrients are required by most crops for them to be absorbed adequately through the leaves.

LIME AND SULPHUR.

Calcium oxide is a soil amendment, but it also supplies an element essential to plant growth. Calcium compounds used for the correction of soil acidity are often termed "limes." Gypsum or calcium sulphate has important soil-improving characteristics, supplies calcium and sulphur to the crops, but does not cause any change in the soil reaction.

Elemental or flowers of sulphur, soil sulphur, sulphur dioxide, sulphuric acid, lime-sulphur solutions and acid-residue fertilizers are used to increase soil acidity.

Soil acidity is described in terms of both lime requirement and hydrogen-ion concentration (pH). Neutrality is stated as pH 7. An alkaline soil would be above this, *i. e.*, pH 7.5 or 8. A very acid soil might be about pH 4.5. This scale is logarithmic, which means that a soil with a reaction of pH 5 is ten times as acid as one of pH 6. It takes roughly about 1000 pounds of hydrated lime an acre to shift the reaction of a sandy loam soil from pH 5 to pH 6. The reaction of a sandy soil is changed more readily than that of a heavy soil because it has less "buffer" action or ability of the soil particles to resist the effect of the lime or sulphur.

A soil reaction that is slightly acid—pH 6 to pH 7—will provide optimum conditions for the growth of soil or legume microörganisms influential in nitrogen fixation and of those concerned in the decomposition of organic matter. Indirectly this affects the availability of other soil constituents.

The injurious effect of acid soils has been explained in several ways. The presence of toxic substances may be a factor. It has been suggested that when soils are limed these toxins may be rendered ineffective but unfortunately other elements which are essential to plant growth may be made unavailable. This whole relationship is complicated by the variation in the constituents determining the reaction of the soil, by the weather conditions and the season of the year. Care must be exercised in the correction of soil acidity.

Calcium compounds improve the physical condition or tilth of heavy soils. This may be largely due to the increased crop residues and extensive root system resulting from the better growth obtained by the application of lime. The production and decomposition of this organic matter cements the fine particles together into granules.

The soil reaction is important in the control of certain diseases,

although the temperature and moisture of the soil also affect the development of the organisms. For this reason some vegetables have to be grown at a range of soil reaction more acid or more alkaline than that at which they would make their best growth. Potato scab and eggplant wilt are less severe if the soil reaction is pH 5.0 to 5.5. Control of club root of crucifers may necessitate a soil reaction more alkaline than pH 7.0.

Vegetables differ in their response to applications of lime on very acid soils, some being very favorably affected, some only slightly and others showing no effect. Zimmerley reports that spinach grown on rather acid soils scarcely resembled the plants of the same variety on soil less acid in reaction. Moreover, crops vary in the degree to which they increase the acidity of the soil while they are growing. Most vegetables make their best growth on mineral soils at a soil reaction between pH 6.0 and 6.8. On muck and peat soils, the optimum range is about pH 5.5 to 6.5.

The crops are listed in Table 9 according to their relative tolerance to soil acidity. Sufficient lime should be applied to bring the soil reaction to the range indicated for the slightly tolerant crops. The very tolerant crops on the other hand might show no beneficial response to an application of lime if the soil reaction were already within the indicated range. However, even with a crop of this type, a small quantity of lime would promote the various soil processes and might even increase growth on certain types of soil, if the reaction were between pH 5.5 and 5.0.

Probably the soil reaction itself over a considerable range has little direct effect on crop growth. Its influence may be exerted through the availability of the various soil constituents. Many of the soils used for vegetable production in the western states have a reaction between pH7 and 8. This natural alkaline reaction does not seem to have the same detrimental effect on the growth of vegetables as does the alkaline reaction produced by the application of lime to acid soils in the East. This may be owing to the greater content of essential elements in the western soils as compared to that of soils in the eastern and central states. Moreover recent experiments suggest that as the soil moisture is depleted there may be quite an increase in acidity at the soil-root interphase which would make soil constituents there more available to the roots.

The white and black alkali soils which develop in the West from the salts left by evaporation require special treatment to make them productive. This involves the application of gypsum plus heavy leaching.

Quantity of Lime to Apply.—The class of soil, its present reaction as determined by a test, the crop to be grown and the form of lime available all influence the quantity that should be applied. It mat-

ters little which form is used as long as it is in a finely pulverized state and is subsequently well mixed with the soil.

Several types of testing kits are available for determining colorimetrically the pH reading of soils. While these tests do not indicate the quantity of lime needed because of the factors mentioned above, they are rapidly made, and do show whether an application of lime is necessary.

TABLE 9.—RELATIVE TOLERANCE OF VEGETABLE CROPS TO SOIL ACIDITY AND THE APPROXIMATE RANGE IN SOIL REACTION DESIRABLE FOR GOOD GROWTH.

Slightly tolerant (pH 6.8 to 6.0)	*Moderately tolerant* (pH 6.8 to 5.5)	*Very tolerant* (pH 6.8 to 5.0)
Asparagus	Bean, lima	Chicory
Beet	Bean, snap	Dandelion
Broccoli	Brussels sprouts	Endive
Cabbage	Carrot	Fennel
Cauliflower	Collard	Potato
Celery	Cucumber	Rhubarb
Cress, garden	Eggplant	Shallot
Cress, water	Garlic	Sorrel
Chinese cabbage	Gherkin	Sweet potato
Leek	Horseradish	Watermelon
Lettuce	Kale	
Muskmelon	Kohlrabi	
New Zealand spinach	Mustard	
Okra	Parsley	
Onion	Pea	
Orach	Pepper	
Parsnip	Pumpkin	
Salsify	Radish	
Soy bean	Rutabaga	
Spinach	Squash	
Swiss chard	Sweet corn	
	Tomato	
	Turnip	

It is rather questionable whether one should attempt to change the soil reaction very greatly by a heavy application of calcium oxide. The shift could be made in several installments or the surface several inches may be modified for a particular crop. Further additions may be desirable from time to time to maintain the desired degree of acidity. In general smaller applications of 500 to 1000 pounds of finely ground limestone at more frequent intervals, that is every other year, are to be preferred to heavy applications every four or five years. They are more economical in that a greater return per unit of lime is obtained and there is less residual effect if the succeeding crop is one requiring a greater degree of acidity. The lime may be spread just previous to the crops in the rotation

which will give the greatest response. A lime-spreader will give the uniform distribution which is necessary if the greatest efficiency of the small amounts of lime is to be realized. Thorough harrowing should follow.

The Form of Lime to Use.—The form of lime to use depends upon the cost per unit of calcium oxide. In some locations it can be obtained more cheaply in one than in another.

Limestone deposits may vary in their appearance and purity. While some often carry as much as 90 per cent of calcium carbonate, others may contain also a percentage of magnesium carbonate. This latter carbonate is considered equal to that of calcium. The magnesium-containing or dolomitic limestone is preferred on the Coastal Plains soils as its use aids in preventing a magnesium deficiency. A hundred pounds of pure limestone (calcium carbonate—$CaCO_3$) when burned will yield 56 pounds of quicklime, lump lime or burned lime (calcium oxide—CaO). If water is added to the quicklime enough will be taken up to form about 74 pounds of hydrated lime or slaked lime (calcium hydroxide—$Ca(OH)_2$). These weights will vary greatly with the presence of impurities, but the relative content of calcium oxide is about as indicated. If lump lime absorbs moisture and carbon dioxide from the air, it is called air slaked.

Oyster shells, marl and blast furnace slag are used as sources of lime when their cost is properly proportional to their content of calcium carbonate.

Limestone and hydrated lime are the most popular forms in use at present.

The Form and Quantity of Sulphur to Use.—Soil sulphur and sulphur dioxide are half and ammonium sulphate but 36 per cent as effective in counteracting alkalinity as is elemental sulphur. It takes roughly 1/3 as much elemental sulphur to increase the soil reaction as a ton of limestone decreases it. Experience and judgment are required in the use of sulphur.

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Chapter 11

CROPPING SYSTEMS

VEGETABLES are grown often as a cash or money crop on general farms. The heavy fertilization and thorough tillage which are necessary leave the soil in excellent condition for the other crops. Potatoes, peas, sweet corn, melons, tomatoes, early or late cabbage following clover are common in three- or four-year rotations with either corn, a small grain or both. The particular crop varies with market facilities or the presence of a canning factory. In the West a common practice is to have vegetables or other cash crops occupy the land for several years between periods in alfalfa.

Rotation.—Rotation means the systematic succession of certain crops year after year. Of course, every crop is grown every year. Fields are laid out so that the grower knows which piece of land will be occupied by each crop in any given year. This appears relatively simple when only a few crops are grown and explains the fact that the intensive vegetable grower does not follow definite rotation to the same extent as the general farmer. Yet it is just as desirable that he do so, especially since it tends to reduce the amount of "plunging" or overplanting of any given crop. Among other gains from rotation of crops may be mentioned the equalization of the depletion of the available minerals in the soil if a leafy crop using large amounts of nitrogen is succeeded by one which is more pronounced in its use of potassium. Similarly one crop may make better use of the decomposed plant parts or manure and the residues of the previous fertilizer application than does some other. A rotation which includes green-manure crops or a sod, especially leguminous, will build up the physical condition of the soil more than will be the result with a one-crop system. When a crop which is a heavy "feeder" is followed by one less exacting in its total use of mineral elements, the normal weathering processes in the soil have an opportunity for replenishing the depleted supplies.

Some crops yield better after certain crops than they do if they follow themselves or even others. Burgess has shown that the inorganic composition of the plants also may be affected. From his work and that of Hartwell *et al.*, this crop effect cannot "be attributed, at least principally, to differences in the amount of nutrients removed by the crops grown previously." The several crops affect the soil acidity differently. They vary also in the distribution and

depth of their root systems, and in the quality and quantity of the organic matter residues they leave in the ground. An injurious effect of one crop on its successor may sometimes be reduced by liming and the addition of phosphorus. The effect of a previous crop may be due also to changes in the physical state of the soil resulting from its condition when cultural operations and harvesting had to be performed.

As a means of reducing losses from insects and diseases, the rotation assumes added importance. When a vegetable plant which is host to a specific disease does not occupy the land more often than every third or fourth year, the disease may be checked. If the spores are able to live in the soil more than four years, greater intervals than these are necessary.

Therefore, unrelated crops should be proximate. Club-root, for example, attacks the members of the crucifer family. Cabbage, cauliflower, radish, turnip, Brussels sprouts, etc., must not follow one another at too short an interval, if club-root is present in the soil. It is interesting to note that varieties of radish, turnip and rutabaga vary widely in their susceptibility to this disease. Some are practically immune.

The rotation should be planned so that as many green manures or cover crops as possible may be grown. Lettuce, green onions, radish and spinach return little waste plant material to augment the supply of soil organic matter. They should alternate with cabbage, peas, beans and the like which leave considerable amounts of humus-forming residues. A shallow-rooted crop may well alternate with one whose roots penetrate to lower levels. Thus, various layers of the soil may be tapped for the elements essential to growth. If foliage crops alternate with root or fruit vegetables the kind and amounts of mineral elements which are needed will be varied. Early and late crops may be used one year with a whole season crop the next year. There are also various economic considerations which enter into the formulation of a rotation. Crop adaptation, method of utilization of the product, and the possible profits cannot be disregarded.

Succession.—Succession planting infers the growing of a second or even third crop in one year on the same piece of land after the previous crop or crops have been harvested and the soil refitted. This practice is common in home gardens and where intensive market gardening methods are followed. It is limited by the length of the growing season and the vegetables selected. Good cultural practices and a program of heavy fertilization are required to obtain proper growth and profitable yields. Careful planning is a prerequisite if two or more crops are to be attempted.

Reference to the classification of vegetables will indicate the crops which might be used in such a system. It is necessary to start or

end with one of the cool-season crops. If the first crop is transplanted, rather than seeded in the outdoor bed, the number of possible successions is increased. The points which are considered in planning a rotation apply equally well in succession cropping.

TABLE 10.—A FEW TYPES OF SUCCESSION PLANTINGS.

First crop.	Succession crop or crops.		
Leaf lettuce Radish Head lettuce Endive Spinach Green onion (sets or plants) Mustard Cress	Lima bean Eggplant Pepper Sweet potato Squash Pumpkin Tomato	or	Rutabaga Late cabbage Late cauliflower Late celery
	Snap bean followed by		Beet, lettuce, spinach, radish, Chinese cabbage, kale, endive
	Sweet corn followed by		Radish, spinach, or winter onion
Cabbage Cauliflower Carrot	Snap bean Sweet corn	or	Beet Lettuce Kale Spinach Turnip
Pea Beet Kohlrabi	Snap bean Sweet corn	or	Lettuce Spinach Chinese cabbage Mustard Late cabbage Late cauliflower Late celery Kohlrabi Rutabaga Turnip Carrot Beet Kale
Snap Bean	Late celery Late cabbage Late cauliflower Sweet corn	or	Carrot Beet Lettuce Turnip Endive
Sweet Corn	Beet Lettuce Turnip Carrot Radish Mustard Kale Spinach		

A few suggestive combinations of crops for succession plantings are given in Table 10.

The term succession is applied by some to *successive* plantings of the same vegetable on different pieces of ground at proper intervals to provide a more or less continuous supply for harvest. Sweet corn may be produced in this way, using a quick-growing variety, and making seedings every two to three weeks. Leaf lettuce, beans, and others are adapted also to this type of planting.

Companion Cropping or Intercropping.—Companion cropping utilizes the garden area even more intensively. It is essentially a system whereby a smaller quick-growing vegetable is planted about the same time as one larger and more slowly developing. The first is harvested and allows the second to utilize the whole area. Intercropping is practised by home and intensive market gardeners but is scarcely practicable in trucking areas where land values are low and the labor supply scarce. High fertility and abundant moisture are necessary for successful intercropping.

Until the early crop is removed it is often difficult to use tools for tillage. Considerable hand-work is necessary and although the total cost of production is greater, it is partly offset by the greater harvest that is possible from a smaller area. Since the cost of preparation of the land is divided between the several crops, this helps further in balancing the greater amount of hand labor. When the land is occupied so completely it is more difficult to spray or dust for the control of diseases and insects. Greater care must be exercised in tillage and harvest to avoid injury to the main crop.

Many possible combinations will suggest themselves, but only those which do not permit the development of the main crop to be retarded should be considered. This involves the length of time it will take the early crop to mature if seeded at a certain time, the type of the growth produced by the companion crops, the distribution of their root systems, and the mineral and moisture requirements of the crops during the time they will be occupying the land together.

Globe radishes may be sown with parsnips to mark the rows, since they germinate much more quickly. Cultivation may be given to control weeds while they are still small. A similar system is possible with salsify or even carrots. A row of upright growing green onions from sets or transplants can be placed between 2 rows of cabbage. There is sufficient space for 1 or 2 rows of radishes between rows of beans or peppers. Well-grown lettuce plants may be set in the row or between rows of cabbage before the latter have need for the space. Any small, early vegetable like spinach, radish, beets, flat turnips or carrots could be seeded instead of lettuce plants between cabbage rows. Turnip seed may be broad-

cast in corn at the last cultivation. The globular radish is perhaps the most ideal intercrop.

Wide-spaced fruit plantings and asparagus beds may be intercropped with annual vegetables until they come into bearing. Each succeeding year the annuals are kept further away from the perennial plants.

Another variation of the system is where the growing period overlaps but little. It is then almost a case of succession cropping. As the pods on early peas are beginning to develop, a few vines may be pulled at 8-foot intervals in every third or fourth row. Winter squash is seeded at these places, and will spread over the whole area when the pea vines are removed.

Spinach drilled in 12-inch rows will be developed by the time for tomato planting. A few spinach plants may be removed in every third or fourth row and at proper intervals in the row to make way for the tomato plants. Bunch onions from sets may be substituted for spinach as the initial crop. If it is desired that part of the onion crop be used green and the rest as mature bulbs, a combination with celery is feasible. Every other row of onions is used green if the celery is to be blanched with boards or paper, and every fourth or fifth if the soil is the blanching medium. Celery plants are transplanted to the vacated row. The mature bulbs will be harvested in time to make room for the last stages in the growth of the celery.

The examples which have been cited indicate the infinite number of possible combinations. A little ingenuity will enable the gardener to make intensive use of the area at his disposal.

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Chapter 12

MOISTURE SUPPLY AND WEED CONTROL

An adequate supply of moisture is essential for profitable growth of vegetable crops. When water comes to a soil by rain or irrigation it moves downward by gravity if there is no hardpan. When movement ceases water will be present in films on the surface of soil particles and in some of the small pore spaces. This stage is the *field capacity* (F.C.) of the soil. When determined in the laboratory it is known as *moisture equivalent* (M.E.). A given amount of water will move to a greater depth in a sandy soil than in a clay because the sand particles are of large size and the spaces between particles are larger than in a clay so less able to counteract the pull of gravity. The finer the soil particles the greater the area for water films. Penetration of water is facilitated by decayed organic matter and by application of lime and gypsum since all these improve the granulation or structure of the soil. The soil when filled becomes a reservoir of water and can lose this in but two ways. That in the surface, 3 inches or so, may be lost by evaporation to the air. The rest stays unless absorbed by roots. When this water is taken up a point is reached at which the plant wilts and dies if more water is not supplied to the soil. This is known as the *permanent wilting percentage* (P.W.P.). The difference between the F.C. and P.W.P. represents the available water. Usually a clay loam will hold more moisture than a sandy soil and have more available water. There are exceptions. In sands the addition of organic matter may increase the available water.

Vegetables differ in the depth to which they root. Most of the cool season crops are shallow-rooted while the warm season ones send their roots to a greater depth provided no hardpan or other physical limitation prevents. Thus as growth advances part of the roots may have reduced the water in their immediate zone to the P.W.P. yet other parts of the root system are getting enough water to keep the plant from wilting. Growth may not be as good as though most or all of the root system were supplying water and nutrients to the top. There is little lateral movement of water in soil, so it is necessary periodically to replace the water used from the reservoir by bringing all the root zone again to field capacity. The roots do not search out for water. They grow where moisture is present.

Moisture conditions in a soil can be helped by irrigation, weed control and the use of mulches.

TABLE 11.—CHARACTERISTIC ROOTING DEPTHS OF VEGETABLE CROPS WHEN NO HARD PAN INTERFERES WITH PENETRATION.
(Adapted from California Agr. Exp. Sta. Lithoprint, 1943.)

Shallow (To about 2 feet)	Intermediate (To about 4 feet)	Deep (To more than 4 feet)
Broccoli	Bean, snap, bush and pole	Artichoke
Brussels Sprouts	Beet	Asparagus
Cabbage	Carrot	Bean, lima
Cauliflower	Chard	Parsnip
Celery	Cucumber	Pumpkin
Chinese Cabbage	Eggplant	Squash, winter
Endive	Muskmelon	Sweet potato
Garlic	Mustard	Tomato
Leek	Pea	Watermelon
Lettuce	Pepper	
Onion	Rutabaga	
Parsley	Squash, summer	
Potato	Turnip	
Radish		
Spinach		
Sweet Corn		

IRRIGATION.

On high-priced land the necessity for getting several crops a year from the same piece of ground requires that the grower obtain prompt germination, the maximum rate of growth and quality. There may be enough water through the season as a whole, but at some critical stage of growth, the ability to supply water may mean the difference between success and failure.

In arid sections the use of irrigation is primarily a means of supplying a water deficit. Under humid conditions irrigation is a form of insurance, so that an optimum supply is always available.

The frequency of application and quantity of water needed depend on many factors. The depth and distribution of rooting by the crop, the size of top growth, thickness of stand and weather conditions (wind, humidity and temperature) affect the rate of removal of water. Young plants may need more frequent applications because of their shallow roots. The water-holding capacity of the root zone as influenced by the depth of the soil, its texture, structure and content of organic matter, and the presence of a water table determine the available supply of water. Under humid con-

ditions an acre inch of rain a week—or equivalent irrigation—will maintain sufficient moisture for vegetables, while in arid or semiarid areas greater quantities of water may need to be applied by irrigation. The rate of use there by evaporation and transpiration may reach a maximum of .4 inch a day.

A safe rule is to fill up the soil reservoir and withhold water until evidence indicates it is needed but before any serious damage has been done. Slight wilting of plants in the afternoon, a slowing down in the rate of growth, and a change of color of the soil in the root zone are aids in developing experience as to the proper frequency of irrigation on a particular soil. Frequent shallow irrigations are wasteful of water. Evaporation losses from the surface

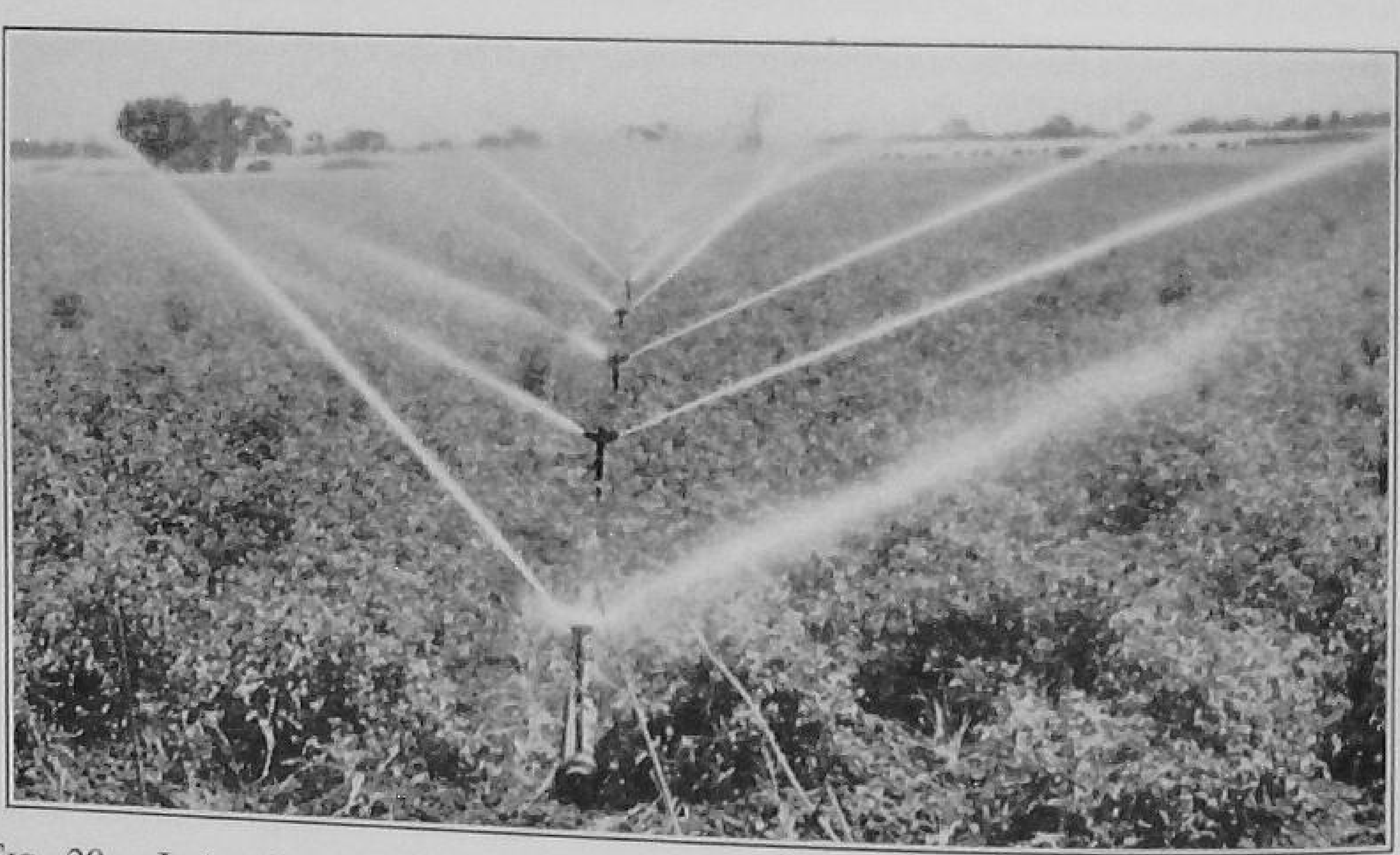

Fig. 20.—Irrigating tomatoes by means of a light-weight pipe equipped with rotating sprinklers. (Courtesy of Food Machinery Corporation.)

3 to 6 inches are increased and the plants will tend to develop a greater percentage of their roots in the upper soil. This is because the moisture in the deeper layers will have been depleted by roots and is not replaced by light irrigations. Frequent irrigations are needed on light soils because they hold usually little available water but their over-irrigation will increase the loss of nutrients by leaching. Too much water applied to a soil underlaid with gravel will waste water and wash valuable nutrients out of the rooting zone. On the other hand such unwise irrigation on a hard-pan soil could result in a perched water table and consequent drowning of the roots.

An acre inch of water supplied to the surface of the soil will replace the available water to a depth of 12 to 15 inches in sands, to 8 to 12 inches in loams, but in clays only to 4 to 8 inches.

Surface Irrigation.—Surface irrigation by means of flooding whole areas or furrows between the rows and beds of crops is widely practised in the arid sections of the West, although it may be used on eastern farms when it is desired that a piece of nearly level land of even contour be irrigated. Proper grading of the land is a prerequisite to successful irrigation in order that the water will flow to the end of the furrows. No low spots should be allowed as the water would flood over the beds and cause the surface to bake and crack. It is desired that the water subs into the beds from the furrows. The

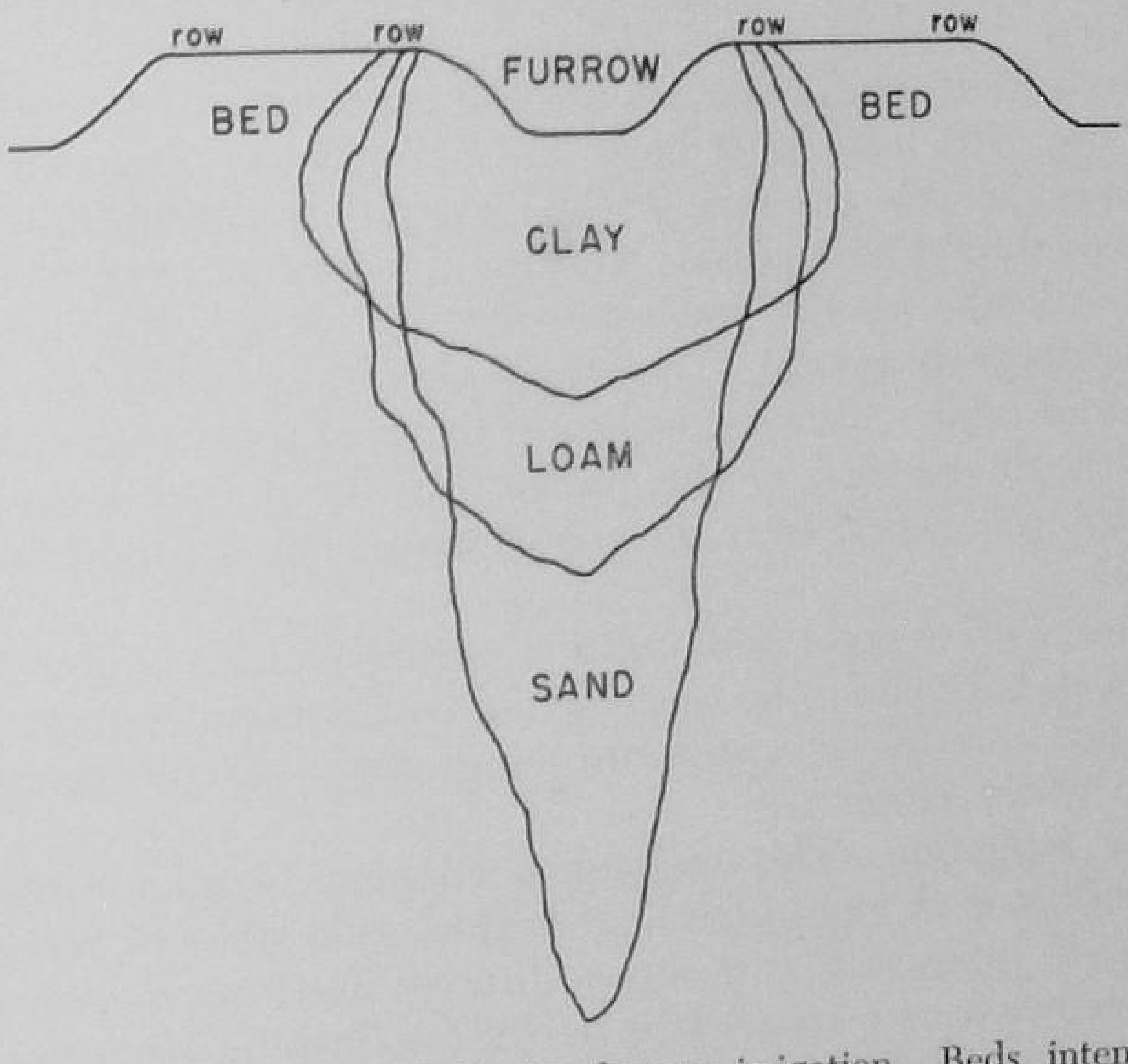

FIG. 21.—Arrangement of beds for furrow irrigation. Beds intended for two rows are usually on 36, 40, or 42 inch centers with the surface 4 to 6 inches above the bottom of the furrow. The depth of penetration of an equal quantity of water varies with the class of soil as indicated. The area under the centers of the beds may be dry in spite of irrigation once the available water there has been removed by roots.

slope provided varies with the texture of the soil from as much as 10 or 12 inches per 100 feet on sandy soils to as little as 1 or 2 inches per 100 feet on clay loams. The length of run should be such as to permit uniform water penetration. This may be from only 100 feet in sandy soil to 1,000 or more feet in clay soils.

The supply ditch, flume or pipe line, with outlets at suitable intervals, is carried across the highest side of the field. The water can be introduced into the furrows through open cuts directly from the head ditch, or from an equalizing basin, or various types of

spiles or spout boxes made of wood, metal, or hose are used through the dam at the head of each furrow. Siphons of metal, plastic or rubber will carry the water over the bank of the head ditch into the furrow. Their initial cost is considerable but their use saves labor.

The rate of flow of the water into the furrows must be greater on a sandy soil than on a heavier one but the time the water runs should be less. A broad shallow furrow provides better distribution of the water than does a narrow deep one.

In arid regions the soil may be flood irrigated before the beds are made with a lister; furrow irrigated before the tops of the beds are leveled off; furrow irrigated after seeding; or a combination of these used.

Subirrigation.—Subirrigation is more exacting in the requirements for its use. The land must be level or slightly sloping. The surface loam must be able to move water by capillary action, and beneath this there should be a porous stratum of a foot or so of coarse sand which will take up the water introduced through the lines of tile and distribute it evenly. The whole should be underlain with an impervious layer. Flowing wells are the best source of water. It is sent through the lines of tile, passes into the porous layer and the water table is raised over the whole area. This method is used in Florida.

Deposits of organic soils with a naturally high water table or impervious subsoil can be subirrigated by temporarily damming the outlet and introducing water into the drainage ditches thereby raising the water table.

Spray Irrigation.—This method is adapted to all classes of soil and conditions of topography. It is the application of water under pressure in pipes so that it comes through fixed nozzles or whirling sprinkler heads as a spray. It is useful for flushing from the surface soil the salts which may accumulate there under certain conditions. The system is good on sandy soils which are too porous to be satisfactorily handled by surface irrigation. It calls for a considerable investment in pipe.

Spray irrigation places the water directly on the foliage of the plants, in contrast to the other systems where it seeps in about the roots. Some claim that water should not be applied in bright sunshine but it is doubtful if drops of water can cause burning of leaves by focusing the rays of the sun like a lens. Since the plants are wet by this system of irrigation there is a much greater loss of water into the air from evaporation than is the case in surface or subirrigation. Irrigations can be made in daytime or at night.

Spray irrigation is recommended as a means of preventing frost injury although sometimes its use has increased rather than decreased the amount of freezing. The theory is that as the mist settles

on the plants it freezes, and gives off heat. Thus, the temperature of the foliage is kept from dropping below the danger point and freezing injury does not occur. This coating of ice thaws gradually the next day under the action of the sun and the continued irrigation. It is possible also that the falling water would keep the air in motion and serve to prevent the formation of light frost on the leaves.

Vegetable growers are shifting away from the old stationary installation that used small-size iron pipes supported on tall posts across the field at 50-foot intervals. This system represented a considerable investment. The nozzles located every 3 or 4 feet along the pipe delivered the water in a fine spray. Automatic oscillators turned the pipe so labor costs were low. Sometimes such lines of pipe were kept portable and moved across the field. They were laid either on the ground or on low supports. The initial investment in this portable system was low but labor costs were great. Any portable type of sprinkler system permits better farming practices than does a permanent one.

Rapid expansion has occurred in recent years throughout the country in the use of light-weight pipe, usually 2 to 4 inches in diameter. It comes in 20, 30 and 40 foot lengths, with quick-acting couplings that speed the job of separating and reuniting the sections when the pipe is moved to its next position. A modification of this system provides wheels at intervals along the pipe. Thus the pipe is across rather than parallel to the rows. It is readily rolled to the next position without the necessity of separating, carrying and rejoining the lengths of pipe.

The outlets for the rotating sprinklers are in the couplings. These sprinklers are placed 20 to 60 feet apart, depending on the quantity of water it is desired should be applied, the flow of water available, and the discharge capacity of the slowly-rotating sprinkler heads. These factors and the wind velocity at the time influence also the distance the pipe must be moved for the next sprinkling in order to get a suitable overlap in the distribution pattern. One must guard against spraying the water on more rapidly than the soil can absorb it.

In a portable installation one end of the sprinkler line is connected at the side of the field to a riser from the underground supply line or to an above-ground portable feeder line. A device is provided on the far end of the pipe which seals itself under pressure but opens and drains the pipe when the water is shut off for the move to the next position.

The supply of water should be sufficient to deliver in an emergency at least an inch depth of water a week over the whole area equipped for irrigation, or about 27,152 gallons an acre a week.

City water, underground water, ponds, lakes, streams and ditches are all good sources of supply. The inlet pipe should be screened in the last four sources if small spray nozzles are used.

The pump and its operating engine or motor are essential features of the system which require careful thought. They must be capable of raising the water to the highest position of the system, overcoming the friction of the passage of the water through the pipes, and maintaining at the nozzle lines a pressure of at least 20 pounds a square inch. The various manufacturers of irrigation equipment will gladly furnish tables by which the requirements of size of pipe, water supply, and power for any layout may be calculated.

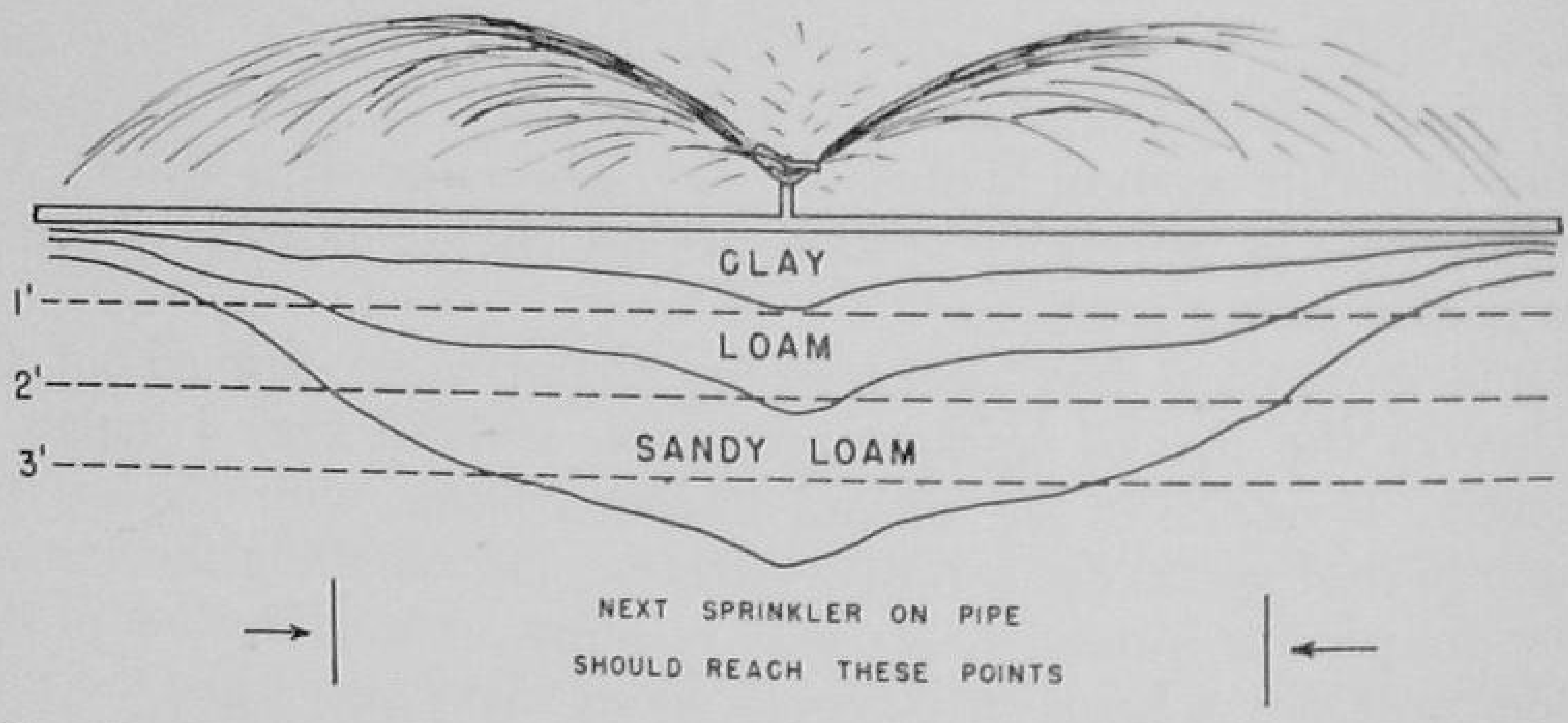

FIG. 22.—In order to avoid uneven water distribution the distance between sprinklers should allow a 40 per cent overlap in the diameter of the area they cover. The diagram shows the approximate depth of penetration of available water from a 3-inch irrigation on various classes of soil.

WEED CONTROL.

The practice of intertillage to control weeds and form a soil mulch is known as cultivation. The early colonists in America followed the well-known Indian custom of planting corn in hills, but failed often to keep away the weeds from these mounded hills. The poor results in crop growth subjected the colonists, according to Carrier, "to ridicule for their shiftlessness by the painstaking squaws." Clam-shell hoes were used by the natives to till just the mounds. Cultivators or "horse-hoes" were used extensively in England before they were adopted in this country. With the use of animals and cultivating tools the stirring of all the intervening ground was found to be the most feasible way to kill the weeds.

Weeds draw on the soil for moisture and minerals, particularly nitrates, which should be solely for the vegetable crop. Weeds may interfere with the light and carbon dioxide supplies of the crop plants. Weed elimination is the primary reason for cultivation.

The weeds should be killed while they are small, before they have had an opportunity to injure the crop; not only because it is easier to get rid of them at that stage, but also to avoid the possibility of injuring the roots of the vegetables by deep cultivation to remove weeds of large size. *Cultivation need only be frequent and deep enough to control the weeds that cannot be killed by other means.*

Since aëration as well as moisture is essential for the activity of microörganisms, fairly deep cultivation while the plants are small might increase nitrate formation and mineral availability in heavy soils which have been packed, or in places in fields where water has settled. It is certain that cultivation cannot take the place of adequate methods of preparing the soil and augmenting the organic matter supply before the crop is planted.

FIG. 23.—Long rows of celery make cultivation easy.

The formation of a surface mulch, to reduce the evaporation of water from the soil, has been advocated as a benefit of cultivation. On sloping land this loose soil may absorb rain to better advantage than a compact surface. Water is lost into the atmosphere if moist soil is turned up and exposed to the air. In the early spring this drying of the soil may be beneficial, but it is scarcely so in summer. Cultivation to produce a loose surface mulch may not in itself conserve more moisture in the soil under many conditions than will be obtained from a dry firm surface layer. Unwise cultivation can actually destroy soil structure and increase soil compaction.

The other important factor which must be considered is the type of root system which is developed by the different crops. In general, each kind of vegetable has a root system pattern which is quite as characteristic of that vegetable as is the above ground portion. However, the lateral extent of the roots, their angle of penetration, and the depth attained may be modified by soil conditions. A

vegetable which develops a widespread network of roots, filling the surface foot of soil for considerable distances about the stem, would permit little or no water to rise by capillarity to the surface between the rows of plants. Frequent deep cultivations will prevent the growth of roots in the rich top soil and may retard, materially, the development of the plants. Pruning of the roots near the surface does not make them go deeper.

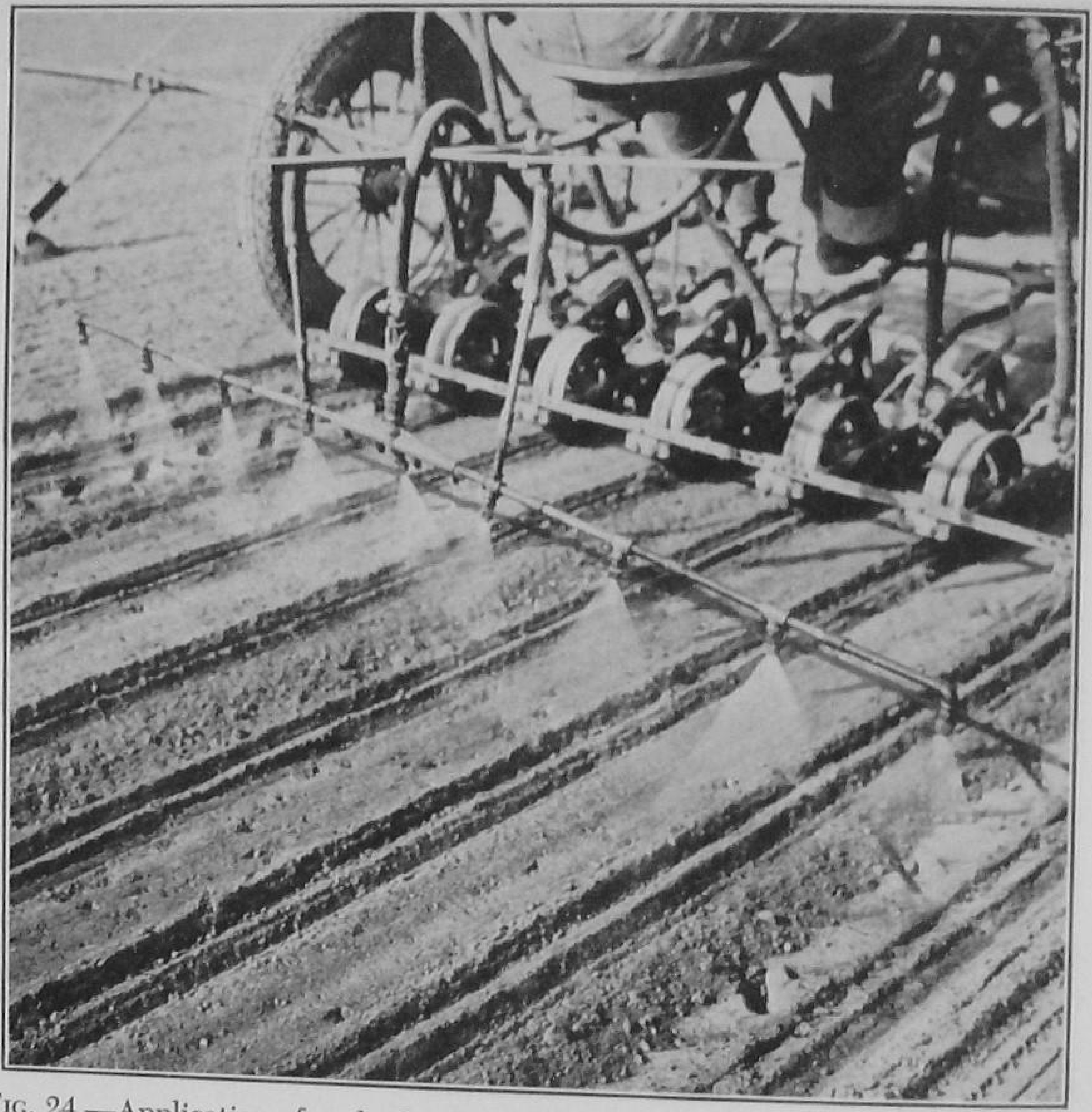

FIG. 24.—Application of an herbicide on the row at the time of seeding spinach. (Courtesy of Seabrook Farms Company.)

Cultivating tools of various types are in use, adapted to hand, horse, or tractor operation, for single or multiple row work. Various types of teeth or shovels are available. To avoid the injurious effect of the cultivator teeth on the roots of the vegetable crop, knives, hoes or sweeps which cut off the weeds just below the surface will be found very effective. They leave, necessarily, also a light soil mulch, which will fill cracks in the soil. Rotary hoes chop off the

weeds and loosen the soil to the depth at which they are set. It is obvious that stirring the soil should be reduced to an absolute minimum. Modern techniques have provided means of chemical weed control that can replace the old methods of killing weeds with cultivation equipment.

Herbicides and Flaming.—Herbicides may be applied (1) when the land is fallow, (2) as a preëmergence spray after the crop is planted, (3) as a preventative to the emergence of weed seedlings after the vegetable crop is established, (4) as a selective spray to remove the weeds from the growing crop. Preëmergence sprays have the distinct advantage over cultivation that there is no danger of bringing more weed seeds to the surface where they will germinate. Rains may make the soil too soft, however, to get a sprayer into the field before the crop plants emerge. Weed sprays can be applied by airplane.

There are a number of chemicals that can be used for preëmergence spraying. Among these are IPC (*isopropyl N-phenyl carbamate*), Chloro IPC (*isopropyl-N-3-chlorophenyl carbamate*), Dinitro amine which is the alkanolamine salt of DNOSBP (*dinitro-ortho-secondary-butyl phenol*), and TCA (*trichloroacetic acid*). Alanap 1 (*N-1-naphthyl phthalamic acid*) is adapted to preëmergence application to vine crops. The light aromatic oils serve particularly well as preëmergence sprays on shallowly-planted or quickly-germinating vegetables because they have no residual effect that might injure the emerging seedlings. Karmex W (*3-[p-chlorophenyl]-1, 1-dimethylurea*) and Crag herbicide 1 (*sodium 2,4-dichlorophenoxyethyl sulphate*) can be sprayed over asparagus beds just before harvesting commences and again at the end of the cutting season.

Corn is the only vegetable which has much resistance to 2, 4-D (*2, 4-dichlorophenoxyacetic acid*) its salts and esters. This material is excellent for the control of morning glory and many other weeds on fallow land. Equipment used in its application must be very thoroughly cleaned before being used for other spraying jobs, in fact it is best not to use it for other sprayings. When a salt of 2, 4-D has been used, let the sprayer stand for 12 hours filled with a solution of ammonia water, 2 teaspoons per quart of water. Then rinse it with hot soap suds and then several times with hot water. If the ester is used rinse the sprayer well with kerosene and then give the above treatment.

Some of the materials suggested for use as preëmergence sprays work equally well as post-emergence or selective herbicides in growing vegetables. Good results have been obtained with the ammonium salt of DNOSBP in peas, and Alanap 1 on the vine crops except for squash. Aromatic oils will kill many weeds with little

damage to carrots and related crops. Celery should not be sprayed after it is about 4 inches high. Dilute sulphuric acid (2 per cent), Sinox (*sodium dinitro-ortho-cresylate*) and potassium cyanate are effective in killing weeds in onions. Common salt (*NaCl*) is employed for killing weeds in beets that are at the stage of four or five true leaves.

Trade names are utilized in the sale of many of these herbicides. Various formulations may contain different quantities of the effective material. Sometimes these are expressed as the active ingredient or as an acid equivalent. The rates and timing of the chemicals must be modified according to the weather and soil conditions, the classes of soil, the species of vegetable and even the variety. Therefore it is most important that the directions provided by the manufacturer be carefully followed.

Research is leading to the use of chemicals for specific types of weeds in certain vegetable crops. Recommendations are changing constantly so it is well to seek the latest information.

Burners using kerosene or propane gas have given good results in destroying weeds just before the crop seedlings emerge. Such flaming has also been used in growing crops of onions, corn, potatoes and lima beans with but little injury when the flame is directed along the ground below the foliage of the vegetable crop.

MULCHING.

When any material is spread over the soil surface the evaporation of moisture into the air is checked in the same way as in the case of the dry layer of surface soil.

Straw, leaves, hay, dead weeds and peat moss are some of the materials which may be spread over the area between plants to check weed growth and retain moisture. The thickness of the mulch depends upon the material employed. Mulching is convenient on small areas and in home gardens.

The temperature under a straw mulch is lower than that of unmulched soil which may account for the delayed maturity which often follows the spreading of the material. The yellow, sickly growth of straw-mulched plants has been thought to be due to the use of available nitrogen by the microörganisms concerned in the decomposition of the straw adjacent to the moist soil surface.

Mulching paper has been tested rather extensively and often has produced quicker germination, increased yields, earlier maturity and higher quality. The practice of paper mulching can be justified probably for the home gardener sooner than for the market garden. It would seem that the paper would be most valuable on early warm-season crops, especially in regions with a short season

for growth, and more generally in a dry summer. However, the cost of the paper, the labor involved in laying it, and the complications to the planting operations have reacted against its widespread use.

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Chapter 13

INSECT AND DISEASE CONTROL

THROUGH modern transportation facilities the various parts of the world are relatively closer than in the days of our forefathers. Increased plantings of vegetables and the more intensive system of cropping play their part also in the wider dissemination of insects and diseases. There is scarcely a vegetable crop from which some pest does not take toll in the form of reduced yield, poorer quality, less attractive appearance, or rapid deterioration after harvest. The total annual cost of the depredations of vegetable insects and diseases in the United States alone equals many millions of dollars. Preventing or reducing these losses is of paramount importance. If control measures are not practised a crop may be almost a total loss, yet systematic attempts to check the development of insects and diseases are expensive and add to the costs of production. In some reasons a disease may be epidemic throughout a considerable area, resulting in a reduced yield, an excess of demand over supply, and consequent higher prices to the buyer. Thus eventually the cost in either case comes back to the consumer.

Timeliness.—Timeliness is of utmost importance in any attempt at controlling pest attacks. The treatment must be applied at the time when it will be most effective.

Frequently an examination of the plants in a field will seem to show little if any indication of disease, and growers may be prone to question the desirability of any precautionary measures. Insect and disease control may be likened to crop insurance. A grower collects his insurance when conditions develop which are favorable to the pest if his premiums have been paid in the form of timely applications of the precautionary measure. Increased yields of potato and celery have been obtained by spraying with Bordeaux mixture, when to the eye there was little disease present. The epidemic stage of a disease is seldom reached for several weeks after the first symptoms are apparent unless the weather is especially favorable to the development of the parasite. Many growers prefer to watch their crops very closely and apply treatment at the first sign of any disease symptoms. With some vegetable diseases or insects this method will be satisfactory but is not recommended as a general practice.

Under many conditions the culture of the cucurbits requires a regular sequence of sprays or dusts. The foliage diseases of tomato, celery and potato can be most readily held in check by a systematic fungicidal campaign.

Appropriateness of Method and Material.—This is an essential characteristic of insect and disease control. Spraying cabbage would not help check the yellows disease, nor would dusting prevent attacks of the cabbage maggot. In order to know just when and what control measures to apply, it is desirable that one be familiar with the life history and appearance in various stages of the insect or disease to be combated. Economic entomology and plant pathology are becoming increasingly important to the vegetable grower, and no student of vegetable gardening is fully equipped until he is well-grounded in the fundamentals of these two fields of science. No attempt will be made in this text to cover the subject matter of economic entomology and plant pathology, but merely to discuss the methods of control available to the vegetable grower. Under the specific crops the more important insects or diseases will be mentioned briefly in order to correlate pest control with crop culture. It is believed that the appropriate precautionary measures pertaining to most of the more common insects and diseases should be taken as a normal step in crop culture since frequently a gardener is unable to identify the parasites in time to apply treatment.

Thoroughness.—Thoroughness is closely allied to timeliness and appropriateness in control work. If the surface of the foliage is to be protected with a film of fungicide, this means *all* the surface, both the upper and lower surfaces for some diseases. New growth must be given its coating as it appears. It is only through the use of adequate machinery that thoroughness can be obtained.

In the preparation of soil for planting, disinfection is important. A sufficient amount of formaldehyde or hot water must be used to reach all the soil particles. The period of heating with steam or electricity must be sufficiently prolonged. If the soil is put into undisinfected flats or walked on with boots which may carry disease spores, the efforts at disease control are largely nullified.

An incomplete job in the application of any control measure is merely a waste of time, money and materials with little chance of any lasting beneficial effect on the crop.

CONTROL METHODS.

In addition to the following general methods there are a number of special treatments which are applicable only to the control of some one parasite. There are several pests also for which no effective control is at present known, such as the spinach leafminer.

After crops are harvested and placed in storage or shipped to market, various diseases often appear. In general the first step in the prevention of storage and transportation losses is the practice of proper control measures on the growing crops. Disease-producing organisms gain admittance to healthy tissue through cuts and other sorts of injury resulting from carelessness in handling at harvest. Thus it is evident that losses from diseases may be either in the field or after harvest.

1. **Sanitation.**—*(a)* The fall clean-up of trash and weeds near and in the cultivated areas will reduce to a great extent the number of insect larvae and adults which are hibernating in this material. If trash is burned any fungous spores contained therein will be eliminated also. While this treatment will appeal to the grower as perfectly logical and while its value has been recognized for many years, it has not been practised to the extent that the results produced would merit. It is fundamental to the control of many insect and fungous pests. *(b)* Destroying dead or diseased plants which appear in the crops will remove a source of infection. This "roguing," is worthy of more serious attention than is usually accorded it. At the first appearance of unsatisfactory development of a plant it should be examined closely. If it seems diseased it should be removed promptly before there has been an opportunity for nearby plants to become infected. After a diseased plant has been handled healthy ones should not be touched until the hands or tools have been disinfected. Diseased plants should not be fed to animals or placed on the compost pile because the spores may survive and later be returned to the soil in the manure.

2. **Fall Plowing.**—This is effective against those insects which hibernate in the soil yet to be productive of results the larvae or hibernating insects must be turned up before they have penetrated below plow depth, but this must not be done so early in the fall that they will have an opportunity of working down again. Severe freezing or frequently the alternate freezing and thawing, even though not severe, is effective in killing organisms.

3. **Crop Absence or Rotation.**—This control measure consists of separating the parasite and its host plant. Mention has been made in Chapter 11 of the relation of *crop rotation* to insect and disease control by providing a period of years before a given piece of land is planted again to the same or a closely related crop if disease has been present. Sometimes it is necessary to avoid planting a given vegetable at all for several years. A *long rotation* must be followed. In certain localities the attacks of the spinach leafminer and the radish maggot have become so severe as to cause gardeners to omit these crops entirely in their plantings.

4. **Trap Crops.**—Early plantings may be made to attract the insects, or plants of a certain vegetable which the insect prefers are grown among those of the crop it is desired to protect. The plants with attached bugs or larvae are removed and destroyed. The pickle worm which does extensive damage to cucumbers in some localities prefers White Scallop summer squash if plants of this are scattered through the cucumber plantation.

5. **Repellents and Mechanical Protectors.**—Coating the plants with various materials is often effective in discouraging the insects from coming in contact with the plants. Lime scattered on the soil surface near the vegetables is fairly effective in repelling slugs. Bordeaux mixture on the foliage of potato, rutabaga and other crops serves to repel the flea beetle and leafhopper.

Mechanical methods also will prevent insects from reaching the crop plants. Screening a frame will protect seedling cabbage or radish from the maggot fly. Paper plant protectors or wire-screen cones will keep away the cucumber beetle from vine crops.

6. **Fumigation.**—Fumigation of greenhouses for the control of white fly and other insects is readily accomplished with calcium cyanide. Because of its deadly properties it must be used with care. Tobacco preparations also are effective against aphids. It is by means of fumigation to kill the insect carriers that the spread of wilt and mosaic diseases of greenhouse crops is reduced.

7. **Seed Treatment.**—Many disease-producing fungi are carried as spores on the outside of seeds or as dormant mycelial threads within the seed coat. Spores on the outside of seeds are fairly readily controlled. Seed treatment is an aid in controlling damping-off and the rotting of the seed if germination is delayed. A combination of a wet seed treatment followed by a dust after drying is sometimes necessary to control adequately all seed-borne diseases. It is well to remember that time spent in seed treatment is apt to be of little value if the seeds are subsequently planted in soil which is infested with disease-producing organisms. Materials used for seed treatment may act by disinfection of the seed, or serve as a protection to the young seedling against soil-borne organisms. Soluble protectants can be sprayed on the seeds. Others are dusted on or applied by the slurry method. This involves making a suspension of the disinfectant in water and coating the seeds with that.

Organic mercury dusts such as *Semesan*, *Semesan Jr.*, *Barbak C* and *New Improved Ceresan* have been found effective for certain seed-borne diseases. *Arasan*, *Phygon*, *Calomel*, *Spergon*, *Red Cuprous Oxide*, *Yellow Cuprous Oxide*, *Copper Carbonate*, *Captan*, *Tersan*, *Zinc Oxide*, and *Bichloride of Mercury* have special uses. Some of these are available in both wettable and non-wettable formulations for the slurry and dry methods respectively. Many of these

are poisonous to humans and must be carefully used. It is well to follow the directions given by the manufacturers and the State Experiment Stations.

The hot-water treatment of seed necessitates careful attention to maintain a constant temperature during the period of submersion. A double-boiler method is used. Since the temperature required is 122° F. for control of blackleg of cabbage and related crops, one is approaching the critical temperature for the protoplasm of the embryo. Reduced germination power is often a result, particularly if the seed is not of the new crop. Seed is heated for fifteen to twenty-five minutes according to the kind, plunged in cold water and then rapidly dried or planted.

Pea and bean seed should be treated soon after harvest to control the weevil. The seeds are placed in a tight container, a shallow dish holding 1 ounce of carbon disulphide for each 10 cubic feet is placed on top of the seed, and the container closed for twenty-four to forty-eight hours. The liquid vaporizes and the gas settles through the seed. The temperature should be 75° F. or higher.

8. **Soil Disinfection.**—Planting clean seed in soil which contains disease-producing organisms is to be avoided. The gardener may treat the soil in flats, hotbeds, coldframes, greenhouses and small garden areas with any one of several methods which will reduce or eliminate the population of disease-producing organisms. Steam, hot water, formaldehyde, electricity, organic mercury, corrosive sublimate and various gases will serve.

The term often used for this treatment is "partial sterilization" or "pasteurization" because not all of the organisms favorable and otherwise in the soil are killed.

A metal-lined box, capable of being securely closed, with some means of admitting live steam is a handy method. The flats of soil are stacked with wooden strips between to allow for thorough circulation of the steam. Holding the soil at 160° F. or higher for fifteen minutes will clear it of damping-off organisms. A simple test indicative of proper heating is the thorough cooking of medium-sized potatoes placed near the center of the volume of soil. The flats may be seeded as soon as they cool. If considerable soil such as the amount that would be used in a hotbed is to be treated the inverted pan or pipe grid method of steaming used in greenhouse work is necessary. These involve the use of high-pressure steam and are not feasible for most gardeners.

Former methods of employing formalin for treating soil puddled the soil and required a wait of nearly two weeks before it could be used. Recent recommendations involve the use of formalin (40 per cent formaldehyde) at the rate of 2½ tablespoonfuls to a bushel of soil or 1 tablespoonful to a flat or to 2½ square feet of bed. The

formalin is diluted in 5 to 6 parts of water, sprinkled uniformly over the surface, and mixed thoroughly with the soil. The seed can be planted twenty-four to forty-eight hours after treatment. The soil is given a good watering after the seeds are covered.

Electricity is being used with satisfactory results for treating soil where steam is not available. Heating elements are buried in the soil, the temperature raised to 129° F. and held there an hour or more. Proper moisture content of the soil is important.

A corrosive sublimate solution, 1 ounce to 15 gallons of water, may be applied at the rate of 1 pint to a square foot of soil at seeding time, or later over the young seedlings at the rate of 1 pint to 5 feet of row. Under some conditions there may be injury to the seed. The organic mercury compounds have been used successfully by some growers.

Carbon disulphide, chloropicrin, DD (a *dichloropropene-dichloropropane* mixture), EDB (*ethylene dibromide*), CBP (*chlorobromopropene*) and other recently-developed chemicals are useful as soil disinfectants under field and plantbed conditions for certain insects or diseases. *Methyl bromide* is excellent for potting soil and plantbed treatment. The liquid becomes a heavy gas when it is released from its container and settles through the soil. It is odorless and extremely poisonous so a little chloropicrin is added sometimes by the manufacturers as a warning agent. Small quantities of soil can be placed in a gas-tight chamber. The fumes will be retained long enough to kill weed seeds, fungi, and insects if a plastic cover is fastened securely over a pile of soil, or on the surface of a bed or frame.

9. **Spraying and Dusting.**—Applying fungicidal and insecticidal materials to the foliage and fruit of growing plants constitutes an effective control against many insects and diseases. Those insects which have biting mouth parts and actually devour the plants are combated with stomach poisons. Those which suck the sap from the cells must be checked by so-called contact poisons. In using this latter type of poison, it is desirable to hit the insects so that the fumes will more surely penetrate the breathing pores. Some of the organic chemicals serve as both stomach and contact poisons, as well as fumigants.

Disease control is dependent upon a thin film of the fungicide spread over the surface of the plant which destroys the spores, bacteria or fungous hyphae which may later come in contact with it. When growth is rapid this film has to be renewed more frequently than when new foliage is developing slowly. In rainy weather two applications a week may be necessary.

Whether fungicides and insecticides should be applied wet or dry is contingent upon a considerable number of factors. The turbu-

lence created by the blast of the duster or sprayer is important in getting the material onto the undersides of the leaves. It is desirable that dew be present to facilitate the adhesion of the dust to the foliage. Spraying can be done regardless of dew.

When dusts are applied by ground machines or airplanes there is danger of the material drifting. This can be avoided by using vapor sprays instead of dusts. More concentrated material is applied by this means than by the conventional type of sprayer. Only a few gallons of liquid are needed to cover an acre. Several different types of equipment have been designed for vaporizing or fogging the materials.

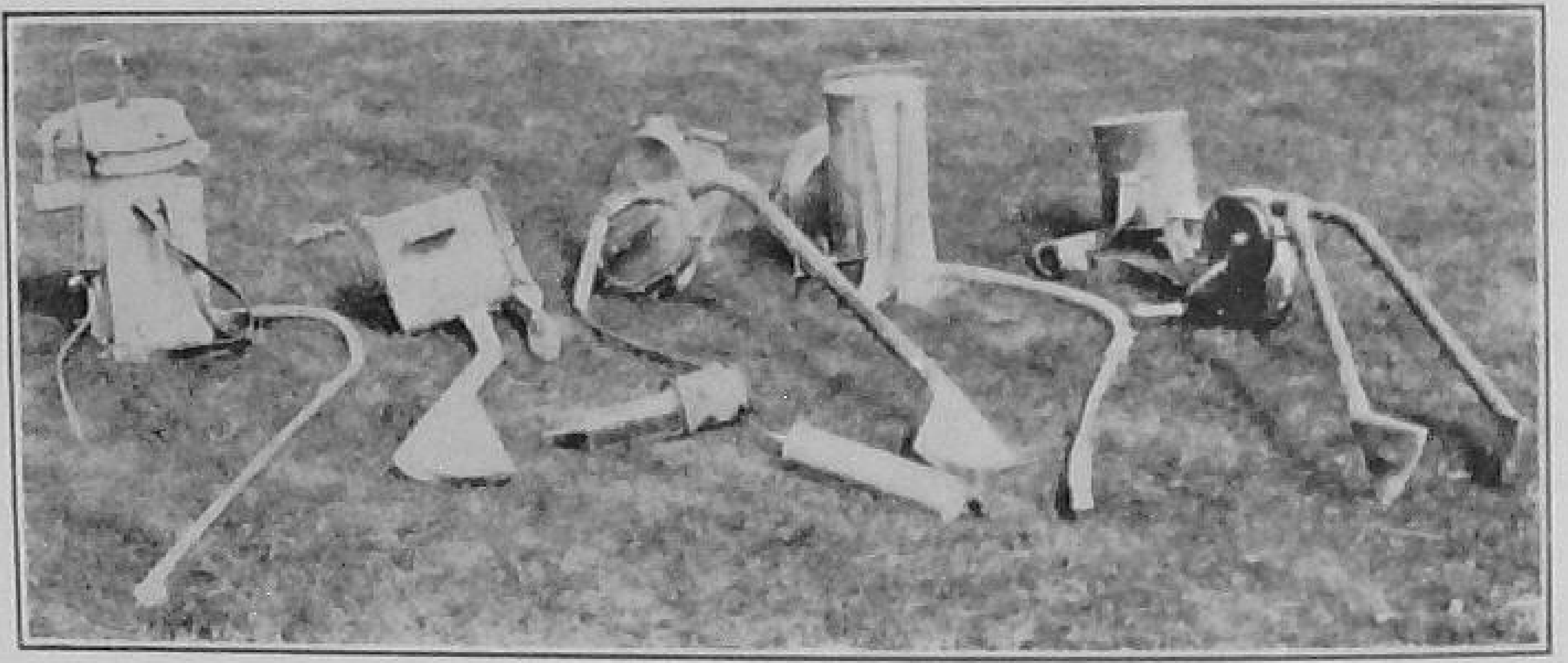

Fig. 25.—Various types of hand dusters.

Sprayers or dusters may be had in various sizes from the hand atomizer or bellows up to the multiple-row engine-driven spray rigs or dusters. The piece of machinery to buy is that one which will give the most economical and efficient service for the acreage to be covered and the conditions, of labor, water supply, soil, kinds of vegetables, etc., under which it must operate.

The *fungicides* used for vegetables represent a great assortment of materials. *Bordeaux mixture* may be homemade or purchased in dry or paste form. The freshly mixed home-made product is preferable and has greater adhesiveness. Common formulae are 4:2:50, 4:4:50, and 5:5:50. When small quantities are needed, Bordeaux of the 4:4:50 formula may be prepared by dissolving 4 pounds of copper sulphate in 5 gallons of water. Then slake 4 pounds of lump lime, strain into the partly filled sprayer and dilute to make a total of 45 gallons. Particles of lime will clog the nozzles. While stirring vigorously pour in the copper sulphate solution. There are some indications that too much lime may reduce the sticking quality of the Bordeaux or injure the foliage of some crops. This has led to the popularity of a 4:2:50 mixture among some growers. Bordeaux mixture will attack iron and steel, therefore all metal parts should

be brass or bronze. All parts of the spray equipment should be cleaned thoroughly after use.

When large quantities are necessary the stock solutions are prepared so that each gallon contains 1 pound of dissolved copper sulphate or lime. Approximately 75 to 100 gallons of spray are required to cover an acre.

The corresponding dust form is known as *copper-lime dust*. Anhydrous copper sulphate ground to pass a 300-mesh sieve is mixed in the proportions of 15 to 20 parts in 85 to 80 parts of fine hydrated lime. This may be accomplished by using a butter churn or small keg fitted with pipe axle and handle. The materials, together with a few egg-sized stones, are placed within and the container rotated for about five minutes. From 30 to 60 pounds of dust are necessary for an acre application.

FIG. 26.—In some localities the onion maggot is a serious pest, causing a greatly reduced stand. (Boyle).

Other fungicides are available that have proved efficacious in the control of certain diseases. Some are prepared both as sprays and as dusts. The "neutral" or "fixed" coppers of low solubility such as the *copper oxychlorides, cuprous oxides* and others are likely to be less injurious to sensitive plants than is Bordeaux. Among the organic chemical fungicides are ferbam (the *ferric*) and ziram (the *zinc dimethyl dithiocarbamate*), Phygon (*dichloro-naphthoquinone*), nabam (*disodium ethylene bis-dithiocarbamate*), zineb (*zinc ethylene bis-dithiocarbamate*), captan (*N-trichloromethylthio-tetrahydrophthalimide*), and also maneb (*manganese ethylene bis-dithiocarbamate*). These materials are available under trade

names in different forms and concentrations. Therefore one should follow the recommendations of the manufacturer when they are used.

The chief *insecticides* that are employed in controlling vegetable insects are the arsenicals, rotenone, pyrethrum, nicotine, and various organic materials. When they are compatible they may be mixed with a fungicide and applied simultaneously. Some come as wettable powders that are readily made into sprays.

Insecticides that are non-injurious to humans and animals are quite desirable. Ground derris or cubé root contains 4 to 5 per cent of *rotenone*. It is mixed with talc to make a dust with a 0.5 to 1.0 per cent rotenone content. For spraying, 2 to 2½ pounds of the rotenone-containing powder is moistened thoroughly with a little water and then enough more added to make 50 gallons of spray. The *pyrethrum* dusts may be ground-up flowers diluted with an inert carrier or the extracts of these flowers added to the talc or other diluent. Rotenone and pyrethrum dusts must be tightly sealed as they lose strength rapidly. *Sabadilla* and *ryania* are others in this group of safe insecticides that give effective control of specific insects.

Compounds containing lead, arsenic, or fluorine are effective against certain chewing insects. The danger of poisonous residue precludes their use on vegetables unless these residues can be removed from the leaves or fruits. *Paris green, metaldehyde,* and *sodium fluosilicate* are used in poison baits.

Nicotine dust is a combination of nicotine with a carrier such as hydrated lime or talc. Dusts containing 3 to 10 per cent nicotine from nicotine sulphate do not volatilize well unless the temperature is above 70° F. The free-nicotine dusts in which the nicotine is in the alkaloid form are effective at lower temperatures. In extensive operations a muslin sheet 20 to 40 feet long is trailed behind the duster and a short curtain dropped ahead of the discharge vents in order to confine the fumes longer about the plants.

Nicotine sulphate may be applied as a spray, using about ½ pint to 50 gallons of liquid. Potash fish-oil soap should be used to spread the spray and liberate the nicotine fumes. From 3 to 5 pounds are needed in 100 gallons of spray material.

Sulphur is incorporated as a carrier in some dusts for vegetables. It does have insecticidal properties for the control of mites. The new organic sulphur compounds are very specific for mites without injuring their natural enemies.

DDT (*dichloro-diphenyl-trichloroethane*) is very effective on many insects. It has a stunting effect on some vegetables, especially the cucurbits. There is also the possibility of injury to humans from residues on plant parts. DDD or TDE (*dichloro-diphenyl-dichlor-*

ethane), and Dilan, a mixture of two nitro-chloro-diphenyls, are less toxic to humans than is DDT but are not as universal in their control of insects. Aldrin, dieldrin, toxaphene, heptachlor, methoxychlor, and chlordane are organic compounds that are recommended for certain insects. Lindane, the 99 per cent gamma isomer of BHC (*benzene hexachloride*) is both a contact and a stomach poison. It may impart an off-flavor to root and tuber crops even several years after it has been put into the soil to kill soil-inhabiting insects.

Extreme care must be taken in the handling and application of the organic phosphates. They can be absorbed through the skin as well as the mouth and nose. Masks, rubber gloves, goggles and protective clothing ought to be worn when these chemicals are utilized. Any ill feeling noticed while applying insecticides, especially the organic phosphates, calls for the immediate attention of a physician.

Of these organic phosphates, TEPP (*tetraethyl pyrophosphate*) is quick-acting with little residual action a day after application. When the others are put on plants all workers should stay out of the fields for two weeks. Parathion (*diethyl nitrophenyl thiophosphate*) and EPN (*ethyl p-nitrophenyl thionobenzenephosphonate*) are among these highly efficient but dangerous insecticides. Malathion (*dimethyl dithiophosphate*) is an excellent insecticide and less toxic to man than is parathion. Most of these chemicals appear on the market under trade names and in various concentrations. Therefore it is necessary to be guided by the manufacturers' recommendations.

Toxaphene, dieldrin, aldrin, DDT, chlordane, lindane, heptachlor and any other persistent chemicals must not be applied to the edible parts of vegetable crops during the 30 days previous to harvest unless such parts are to be very carefully washed or peeled.

New systemic poisons have been developed that are absorbed by the plant thus killing the insects when they start to feed. These materials must not be used on vegetables grown for food. They will be the ideal insecticides when some are found that are not injurious to warm-blooded animals including man.

10. **Control of Environmental Factors.**—It is possible to regulate the environmental factors under some conditions so that certain physiological diseases may be avoided. A particular combination of factors may also decrease the susceptibility of the crop to attacks of some pathogen. Manipulation of environment is accomplished more easily under glass than in the open.

Among the physiological troubles which might be mentioned is the blossom-end rot of tomato. This is induced by conditions favoring a more rapid loss of water from the tops than entrance through the roots. Calcium utilization may be involved.

Adjusting the humidity and temperature of the air in a greenhouse or sashbed through ventilation provides a relatively easy method of controlling various mildews and leaf molds. Loss of seedlings from damping-off can be reduced if the plants and surface soil are kept dry and the temperature as low as is consistent with good growth. Onion mildew may be partially controlled in the open by using a well-drained soil, and having the rows in the direction of the prevailing winds so they may dry out more rapidly. White rot of onions, cabbage yellows and fusarium wilt of tomato are affected in their development by soil temperature and often also by soil moisture.

Apparently it may be possible to adjust plantings so that soil or environmental conditions may be unsuitable for the pathogen. This is a feasible method of insect control also, in that cabbage-maggot emergence is reduced at higher temperatures. Early spring and late summer plantings of beet and spinach will escape severe attacks of the leafminer.

The acidity of the soil may be adjusted in such a way that it is too alkaline for the development of the club-root organism, or too acid for that responsible for potato scab.

A high degree of soil fertility will enable plants to grow rapidly. Thus they will suffer less from insect ravages and outgrow them more quickly. The vigorous plant may suffer less from disease injury than its weaker relative. This is especially true of the diseases caused by the lower types of parasites, but does not hold for many of the more highly specialized parasites such as rust fungi. With certain pests which produce several broods a year it is possible to complete the growth of the crop before the time at which the greatest injury might result.

11. **Disease-resistant Varieties.**—No other method is available in the case of many plant diseases than to use varieties which have a high degree of resistance to the particular disease. Plant breeding for the development of resistant varieties will continue to be of extreme importance in leading the way to successful crops under disease-prevalent conditions. Sometimes these varieties are lower yielding than the standards which one might wish to plant, but with others high-yielding characters have been combined with disease resistance.

Without doubt this method of disease control will become increasingly valuable in the future. It aids in reducing costs of production since it eliminates the expense incident to the practice of protective measures.

Selection for disease resistance must be made with a specific disease in mind. In other words, a variety of cabbage resistant to

yellows would not be necessarily resistant also to club-root, black-leg or some other disease.

12. **Biological.**—There are insects which prey upon those we wish to control. They are sometimes propagated and released in vegetable fields. One feeds on the white fly, another on the European corn borer and the well-known lady bug helps hold aphids in check. Unfortunately some of the insecticial control measures destroy these natural enemies of vegetable pests.

GENERAL CROP INSECTS AND DISEASES.

There are a number of insects which are rather general in their choice of plant hosts.

White Grubs, which are the larvae of the May beetles, are common in land that is in sod. The beetles prefer to lay their eggs in land which is in small grains, timothy or weeds. Clean culture reduces their numbers. Fall plowing is effective, and if chickens and hogs have the run of the newly plowed land, large numbers of grubs, cutworm and wireworm larvae will be devoured.

There are some 7 species of *Blister Beetles* which attack vegetables. They are elongated, rather long-legged, somewhat soft-bodied insects. Dusts containing 5 per cent DDT or 1 per cent parathion or the equivalent sprays will give effective control.

Cutworms, so named because they cut off the seedlings near the ground, are the long smooth larvae of large-bodied moths. Clean culture and fall plowing are recommended. On a small number of plants cardboard collars will do. If there is no danger of poisoning chickens or small animals, a bait may be placed near the plant in the evening. The bait of 2 ounces of Paris green, 1 cup of cheap molasses, 2½ pounds of bran and enough water to make a crumbly mash is sufficient to protect a ¼ acre. The juice and chopped rind of an orange or lemon adds a flavor to the mash. Sodium fluosilicate may replace the Paris green. Another way to check cutworms is to dust the surface of the soil ahead of plant setting or later around the stems of the plants with 5 per cent DDT or chlordane. Spraying the surface with 2 pounds actual DDT or 3 pounds actual toxaphene per acre is satisfactory.

Wireworms are the slender, hard, brown, worm-like larvae of click beetles. They spend at least three years in the soil and emerge the fourth year as beetles. Thus, it takes some time to get rid of them. EDB can be injected into the soil at a rate of 2 to 4 gallons of actual EDB per acre. Equipment for injecting the liquid into the soil in large and in small scale operations is available. Six to eight pounds of actual chlordane, 3 to 5 pounds of actual aldrin, or 2 to 3 pounds of actual heptachlor can be spread as a spray or dust and

disked into the surface soil before planting. These materials should not be used where potatoes are to be grown. Treatment of vegetable seeds with lindane plus a fungicide has given good control.

Aphids or Plant Lice can be controlled with well-timed use of nicotine, rotenone or some of the organic phosphates as a spray or dust. When the later are used two to three weeks must elapse before the vegetables are eaten.

Flea Beetles are small shiny dark-colored insects which riddle the foliage with small pits. They leap vigorously when disturbed. A clean-up of trash and rubbish near the garden will destroy many hibernating beetles. Bordeaux mixture will serve as a repellent, or the plants can be coated with a 1 per cent rotenone or 3 per cent DDT dust, or comparable spray.

Slugs are active at night. Hydrated lime spread near the plants helps repell them. Commercially prepared slug baits are available, or one may mix seven metaldehyde tablets (28 grams) in each pound of moistened bran. This poison bait is scattered broadcast or placed in little piles about 2 feet apart. It takes 40 to 50 pounds of bait per acre.

Nematode Worms are responsible for the overgrowths known as the Root-knot disease, and are microscopic ell-worms existing in the soil in sections where the winter temperatures do not fall too low. Summer fallowing in hot climates will kill off the nematodes in the upper layers of soil. The best control is the injection of 20 to 30 gallons of actual DD or 3 to 6 gallons of actual EDB to the acre while soil temperatures are above 50° F. Experience has shown that greater quantities than these may be needed on soils containing considerable organic matter. Special equipment is helpful in large operations. In frames, plantbeds, or gardens the area can be marked off in 1 foot squares. At each intersection a hole 6 to 8 inches deep is punched. Into each hole is poured ½ teaspoon of the fumigant. A weed gun that meters the liquid eliminates the preliminary hole making. Soil is scuffed into the hole. Pressure with the one's shoe seals in the fumigant. A light sprinkling with water helps also. Another way is to make furrows 6 to 8 inches below the soil surface at 1 foot intervals across the area. A ½ pint of the fumigant is poured along the bottom of 80 to 90 feet of furrow. The soil should be replaced immediately and firmed slightly. It is necessary to delay planting for two weeks after fumigation with DD or EDB.

Spider mites, some red, others spotted, attack many vegetable crops. The miticides containing organic sulphur are very effective as sprays or dusts. Finely ground sulphur is good also but must not be put on cucurbits.

The *European Corn Borer* tunnels into many vegetables, weeds and grasses. The mature larval stage is about 1 inch in length and ⅛ inch in diameter, of a yellowish color with a black head. Control measures are: clean fall plowing; sanitation; and feeding, burning or ensiling the fodder right after harvesting the ears. Beginning when the eggs hatch a 5 per cent DDT dust or a spray consisting of 2 pounds of 50 per cent wettable DDT powder in 100 gallons of water should be applied to all the plant foliage. Three more applications should follow at five-day intervals. A 40 per cent ryania, a 1 per cent rotenone, or a 1 per cent parathion dust are other possibilities, as are the equivalent sprays.

The *Japanese Beetle* is controlled by a 5 per cent DDT dust or a spray consisting of 2 pounds of 50 per cent wettable DDT in 100 gallons of water applied before the edible parts of the plant develop. Some protection can be given in later growth stages with rotenone as a spray or dust.

Besides those diseases which are rather specific there are others which are found on any of several hosts. The loss of plants through a rotting or *Damping-off* of the stem close to the surface of the ground is a common occurrence with many kinds of vegetable seedlings. Proper moisture and temperature conditions and seed treatment will serve to reduce the attacks of the half dozen or more fungi which are capable of producing this disease condition.

Rhizoctonia or *Stem Rot* is known to affect at least twelve common vegetable crops. The treatment varies with different crops.

Bacterial Soft Rot occurs on vegetables in the field as well as in storage and during shipment to market. Rotation and care to avoid injuring the vegetables during harvest are suggsted control measures.

The *Sclerotinia Rot* is prevalent on fifteen or more vegetables in the North, both in the field and in storage. It is caused by a soil organism so that sanitation, rotation and soil disinfection are about all that can be offered. In the South the *Sclerotium Rot* is widespread. Methods similar to the above can be used.

Crown Gall is caused by a bacterium which invades the tissues of the vegetables and stimulates the production of a tumor. It is likely to be present on any vegetable crop planted in infested soil. The only control is a rotation of immune crops such as corn, oats or sorghum.

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Chapter 14

THE GARDEN LAYOUT

THE home garden, whether it be a city, suburban or farm proposition, is a valuable means of supplying the vegetable needs of the family. Dietitians advise that the daily menu should include at least two vegetables other than potatoes. Leafy vegetables are especially desirable. Too often these are lacking if they must be purchased at the corner grocery. In the case of the farm family this source is not available. There is little doubt that more fresh vegetables are used if they are home-raised than if they must be purchased.

The home garden is a year-round agent for good health, because if properly planned it produces fresh vegetables from early spring until late autumn and yields a surplus to be canned, dried or stored for use during the remainder of the year. In addition to being a convenient source of food for the table, the garden can return $1.50 or more for every hour of labor expended. Thus it may become one of the most profitable enterprises of the farm, and for the city dweller a method of reducing materially the expenditures for food. Vegetables such as wrinkled peas, snap beans and sweet corn deteriorate quickly after harvest. Therefore if they can be prepared for table soon after they have been separated from the plant, the highest quality of edible product will be obtained. Furthermore, if the planting plan is made with care, and soil conditions are at all favorable, the work of operating the garden ceases to be drudgery. It becomes instead a pleasure, an inspiration, a means of recreation for office or mill-worker and a possible family enterprise in which all members may have a share.

Location.—In many cases there is little or no choice offered as to the place in which the garden is to be developed. It is desirable that the place selected be near the house since much of the care will be given in odd moments; the harvesting will be done largely by the women folk as food is needed in the preparation of meals; a convenient supply of water for transplanting work, for watering or irrigating is usually to be found at the house. In some sections it is well to have the house on the north or northwest of the garden plot so that it will serve as protection against cool winds and interfere less with light. Trees also serve as shelter, but the garden should be far enough away from any large trees to avoid excessive

shading. The widespreading tree roots will compete with the vegetables for moisture and fertility.

When it is possible to utilize a southern or southeastern slope a somewhat earlier start will be possible in the spring. The slope will provide air drainage with less frost injury. Where there is a choice of soil a good loam which is well-drained will aid in the early spring plantings, but if too light will be likely to produce lower yields through the main part of the season.

Size.—How large a garden to plant depends upon the area at hand, the time available for its care, the number of members in the family for whom vegetables are to be provided and whether all or only part of the supply is to be raised.

Fig. 27.—A farm garden showing diversity of crops and long easily cultivated rows.

It is surprising how large an amount of vegetables may be gathered from a small plot if some thought is given to correct spacing of plants, the use of succession and intercropping schemes, and the proper care of the growing plants. When the gardener is restricted in his area he should confine his efforts to the quick-growing crops.

It must be borne in mind that the successful garden furnishes a constant supply but avoids a glut of any given crop except when the surplus may be canned. More than one planting of snap beans should be made, each being equivalent to but a part of the total row length required for the full year supply.

In suburban and farm gardens where space is not so limited a little larger area may be included in the garden plot. A third of this may be planted each year in a soil-improving crop and a simple

rotation practised. In more restricted gardens reliance must be placed largely on manure for the maintenance of the organic content of the soil.

Shape.—The oblong garden is to be preferred to one more square in shape, although this consideration also is governed by the outline of the land to be used.

The long narrow garden may be seeded and cultivated in less time than one with shorter rows, where a greater number of turns are necessary. This becomes an important factor if horse cultivation is practised but is an advantage even with wheel hoes. The patchwork-quilt garden is distinctly a hand proposition. It is expensive in labor and not readily adapted to good gardening methods. Many home gardens are laid out in this way—a little block of this vegetable and a little block of that. Sometimes each patch is spaded up as needed, and a central path laid out with others at right angles to it. Too often with this arrangement an excessive amount of valuable space is devoted to unproductive paths. An advantage claimed is that one may desire but a few feet of any particular vegetable and the short rows of the patchwork garden are adapted to this sort of planting. On the other hand, it is simple to group such plantings in a single row of the long-row garden.

If the garden slopes much, it is well to have the rows cross the slope to avoid washing and this may justify shorter rows than otherwise would be desirable.

The number of rows which will fit into any given shape and size of plot varies with the space between rows. When hand operated tools are used the distance may be as close as 12 inches for the small-growing types—onion, spinach, radish. Those which spread more—for example, chard, bean, carrot, or beet—should be allowed about 18 inches while cabbage, cauliflower, staked tomatoes, celery and others will want a space of 24 inches or so between rows. Certain others, such as the New Zealand spinach and vine crops, will require still wider rows.

Arrangement.—A garden plan showing the planting scheme is the first step in garden making. Such a plan leads to greatest efficiency in garden management and may be expected to result in a greater total yield from the plot than if the operations are more haphazard. This plan shows the location of the crops, probable date of planting, the space between and in the row, the variety of each crop to be used, intercrop and succession plantings and gives an exact basis upon which the seed order may be prepared. It is desirable that rather heavy paper be used, because it will be roughly handled in the garden as seeding proceeds. It may be filed away for future reference. No plan is perfect and notes may be made on the margin as the crops develop, by which faults may

be corrected another year. By consulting the plan of the previous year the gardener may avoid placing the same or some related crop on the place where it has been growing the preceding season.

Individual likes and dislikes vary so widely that a plan providing for a certain length of row of each vegetable which would meet the needs of one family would scarcely be adaptable in its entirety to another family.

TABLE 12.—A FOOD BUDGET FOR THE GARDEN.

(Adapted from New Hampshire Ext. Bull. 104.)

	Amount to be grown for one person.	No. of times served.	Amount to be used during growing season.*
Asparagus	8 lbs.	20	3 lbs.
Beans, snap	16 lbs.	60	8 lbs.
Beans, dry	16 lbs.	100	
Beans, lima, or green-shelled	20 lbs.	30	5 lbs.
Beets	14 lbs.	40	4 lbs.
Broccoli	20 lbs.	20	10 lbs.
Cabbage	24 lbs.	95	10 lbs.
Carrots	25 lbs.	80	10 lbs.
Cauliflower	8 lbs.	20	4 lbs.
Celery	10 lbs.	40	4 lbs.
Cucumbers	10 lbs.	25	5 lbs.
Greens: beet tops, Brussels sprouts chard, dandelion, endive, kale, mustard and spinach	34 lbs.	75	20 lbs.
Lettuce	18 lbs.	75	18 lbs.
Onion	20 lbs.	50	8 lbs.
Peas	30 lbs.	75	15 lbs.
Potatoes	160 lbs.	450	27 lbs.
Rhubarb	8 lbs.	40	4 lbs.
Root crops: parsnip, radish, rutabaga, salsify and turnip	20 lbs.	65	10 lbs.
Squash and pumpkin	18 lbs.	35	4 lbs.
Sweet corn	60 ears	50	30 ears
Tomato	95 lbs.	260	35 lbs.

*The balance is to be stored, canned or frozen.

Nutrition workers have formulated tables giving the amount of certain of the vegetables which the average person should consume either fresh, dried, preserved or canned during the course of a year. Seldom do these agree in all particulars. One such is given in Table 12. It must not be inferred that each person must eat all of any one of these vegetables. Substitution of similar sorts is possible—one leafy vegetable for another. Nor is it always practicable to attempt to furnish so completely the vegetable supplies from the home garden. With this information in mind, it should be possible by consulting

Table 4 giving the probable yield per 100 feet of row and, by remembering the family preferences, to plan a garden that will supply that part of the vegetable needs for which space is available.

The perennials, asparagus, rhubarb and herbs, should have a place in every garden where a strip can be spared at one side of the area cropped with annuals. Thus they do not interfere with plowing and fitting the soil. Winter onions may be placed with these to advantage.

The annuals should not grow on about the same spot each year but may be grouped and the location of these groups rotated. The first group to consider includes those crops which will occupy the ground the whole season. Salsify, onion, chard, parsley, parsnip are found here. They may be placed next to the perennials one year and in a strip further over in the garden the next season. Pepper, lima bean and eggplant are warm-season crops which remain all season and may be placed near those planted earlier.

A very considerable number of vegetables fall in the quick-growing group. If these are planted together at the early seeding, it simplifies the problem of successions. Some will be used for inter-crop plantings in other places where later seedings of warm-season crops will be made.

It is well to have the crops which are rather tall or spreading in their development on one side so that they will not shade or over-run the others. Sweet corn, pole beans and the vine crops are of this nature. If the rows run east and west then these may well be to the northern side. On the other hand, if the rows are north and south in their direction it is perhaps best to have the tall crops on the east side. Some gardeners train their tomatoes and pole beans to a fence.

There are other crops especially those for late harvest which do not fall into any of these groups. They may be planted wherever they seem to fit best.

Vegetables somewhat similar in their habit of growth and time of maturity may be planted in the same row. This is helpful since but part of a row is all that is needed of some crops. When a small-growing vegetable such as spinach is to be located alongside of one like cabbage which takes a wider spacing, the distance to be allowed between these two rows may be the average of the individual requirements; in this case about 18 inches.

The varieties most useful in the home garden are not necessarily those adapted to commercial planting. For the home table high quality is preferable to heavy yield. Therefore successive plantings at intervals of one or two weeks of a variety of high quality will give a better product than the use of early, mid-season and late varieties.

Management of Garden Soil.—Drainage is improved by the use of tile or stone drains, the incorporation of sand or coal ashes, and fall plowing. Unless plenty of manure or compost is available, the advantages of growing a cover crop such as rye to be turned under in the spring will outweigh those of fall plowing. About 2 or 3 pounds of rye seed to 1000 square feet can be raked or harrowed in as soon as the crops are removed. Oats should be used instead of rye if the garden has to be spaded by hand. When gardens are spread with 20 tons of manure (1 pound per square foot), 2½ pounds of superphosphate should be broadcast to each 100 square feet. When little or no manure is available, then about 5 pounds of fertilizer of an analysis as 5:10:5, 5:10:10 or 10:10:10 should be distributed on each 100 square feet.

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Chapter 15

STORAGE

Improvement in the facilities for storing and shipping fresh vegetables has been an important factor in making a year-round supply available to the consuming public, and in reducing decay, shrinkage and loss of quality. The storage period may be only a few days in length or may extend several months. Fresh vegetables in the Far West and South are placed under cold-storage conditions in a refrigerated car or truck and rushed to the eastern or northern markets. This is essentially temporary storage. Bunched carrots from distant shipping sections compete with bushel goods and reduce the profits of local growers in storing this crop. In fact the improvements in shipping methods are eliminating much of the need for nearby storage.

During the growing season the market may be temporarily over-supplied with early cauliflower or some other product. Often commercial cold storage will carry some of the crop through this trying period to better values. This practice tends to stabilize prices and give greater cash returns. A market gardener operating a roadside stand with other market connections might be justified in having a small unit of refrigerated storage.

In addition to supplying the market with fresh produce at a time when the local-grown product is out of season, and opening up the possibility of truck raising in areas remote from terminal markets, the storage practice has other benefits for the market and home gardener. Consumption is increased by the extension of the period throughout which vegetables are to had on the market. The grower is able to keep in contact with his market for a greater number of months. He need make less effort in the spring to recapture his market outlet.

For the home gardener storage lengthens his fresh-food supply, reduces the amount that needs to be dried, canned or frozen and prevents wasting the surplus yield of the garden plot.

FACTORS GOVERNING STORAGE.

In order to store successfully any vegetable there are certain fundamental requirements which must receive careful consideration.

Temperature.—This is of primary importance in transit and in

storage. The requisites of the various vegetables as indicated in Table 13 differ somewhat. Vegetables commence to deteriorate as soon as they are removed from the plant or soil. As an illustration a vegetable might have an edible usefulness (shelf life) of thirty days at 32° F., and only four days at room temperature (70° F.). If it were held at 32° F. for fifteen days it could be expected to remain useable for only two days after it was brought to room temperature because half of its shelf life would be gone.

The cool season vegetables and sweet corn are best held at 32° F. which is as close to their freezing point as is usually practical. Potatoes are the exception among the cool season crops because sugar accumulates if they are held below 40° F. Should the warm season vegetables be held very long below 50° F. they will show a rapid breakdown, known as chilling injury, when removed later to room temperature for a period of marketing. This would not be a factor if they were to be eaten at once after being taken from the place of cool storage. Thus the best temperature as far as quality maintenance is concerned may not be the same as the lower one that would give the longest storage period.

The rate of chemical change within the tissues of the stored vegetable is affected by the temperature. This is especially so in the case of those vegetables such as peas, sweet corn and asparagus—the quality of which is dependent on a high sugar content.

Cooling of vegetables in a car, truck, or storage room involves the removal of heat from several sources. The most important is the sensible or "field" heat of the product, containers, or walls of the enclosed area that has been accumulated in the environment to which these have been exposed. The total sensible heat equals the specific heat of the particular substance multiplied by its weight. The vital heat that is produced by the respiration of the living produce is sometimes a factor. It is greater the higher the temperature. Heat may leak through the walls, or be generated by any mechanical device within the cooled space. The quantity of ice or refrigeration must be such as to counteract the total heat from these various sources.

The temperature of the more perishable products should be reduced to at least 40° F. as quickly as possible after harvest. When being prepared for shipment, this can be well accomplished by placing layers of crushed ice in the crates or packages. Crops like asparagus, Boston lettuce, celery and beans which are not adapted to package icing should have their field heat removed by pre-cooling in a refrigerated car, cold storage room, or ice-water bath. Vacuum-cooling which is dependent on the evaporation of moisture from the produce for the reduction in temperature is useful especially for the leafy vegetables such as lettuce.

TABLE 13.—THE TEMPERATURE REQUIREMENTS FOR HOLDING VEGETABLES IN STORAGE OR TRANSIT.

Vegetables	Average freezing point (°F.)†	Recommended temperature (°F.)	Approximate number of months to be held
Asparagus	29.8	32	⅓
Bean, snap	30.2	45–50	⅓
Beet, topped °	26.9	32	5–6
Broccoli, sprouting	29.2	32	⅓
Brussels sprouts	......	32	1
Cabbage	31.2	32	5–6
Carrot, topped °	29.6	32	5–6
Casaba melon	......	50–55	1–1½
Cauliflower	30.1	32	1
Celeriac, topped °	......	32	5–6
Celery	29.7	32	2–3
Chinese cabbage	......	32	5–6
Cucumber	30.5	50–55	½
Eggplant	30.4	50–55	½
Endive	30.9	32	1
Garlic	25.4	32	6–7
Honey Dew melon	29.0	50–55	½–1
Horseradish	26.4	32	5–6
Kohlrabi	30.0	32	5–6
Leek	29.2	32	2–3
Lettuce	31.2	32	1
Muskmelon	29.0	45–50	⅓–½
Onion	30.1	32	6–7
Parsnip, topped °	28.9	32	5–6
Pea	30.0	32	½
Pepper	30.1	50–55	1
Potato °°	28.9	36–40	5–6
Pumpkin	30.1	50–55	5–6
Radish, winter	......	32	2–4
Rutabaga, topped °	29.5	32	5–6
Salsify, topped °	28.4	32	5–6
Spinach	30.3	32	$\frac{1}{3}$–$\frac{1}{2}$
Squash	29.3	55–60	5–6
Sweet corn	28.9	32	¼
Sweet potato	28.5	55–60	4–6
Tomato, mature green	30.4	55–60	½
Tomato, ripe	30.4	45–50	⅓
Turnip, topped °	30.5	32	5–6
Watermelon	29.2	50–55	½–¾
Witloof chicory roots	......	32	5–6

° When root crops are marketed in bunches with tops attached the holding temperatures should be the same as those indicated for the topped product, but the holding period can be only ten to fourteen days.

°° Potatoes held for chipping should be at 50–60° F.

† From U. S. Dept. Agr. Cir. 278.

Moisture.—The proper humidity of the storage room varies with the crops. Pumpkin, squash, onion, and garlic keep best in a dry atmosphere (70 to 75 per cent relative humidity). Most of the other crops should be given a higher humidity in order to prevent shrinkage. Cool season vegetables should have 90 to 95 per cent and the warm season ones 80 to 90 per cent relative humidity. Too high a humidity without a compensating low temperature may favor decay, sprouting and rooting.

The humidity of a common storage can be increased by sprinkling the floor or by admitting moist air from the outside. Humidifiers of various types are used sometimes in cold storages. Excess moisture can be taken from the air by blowing it over a drying agent such as calcium chloride, or in the case of a common storage by letting in dry cold air from the outside.

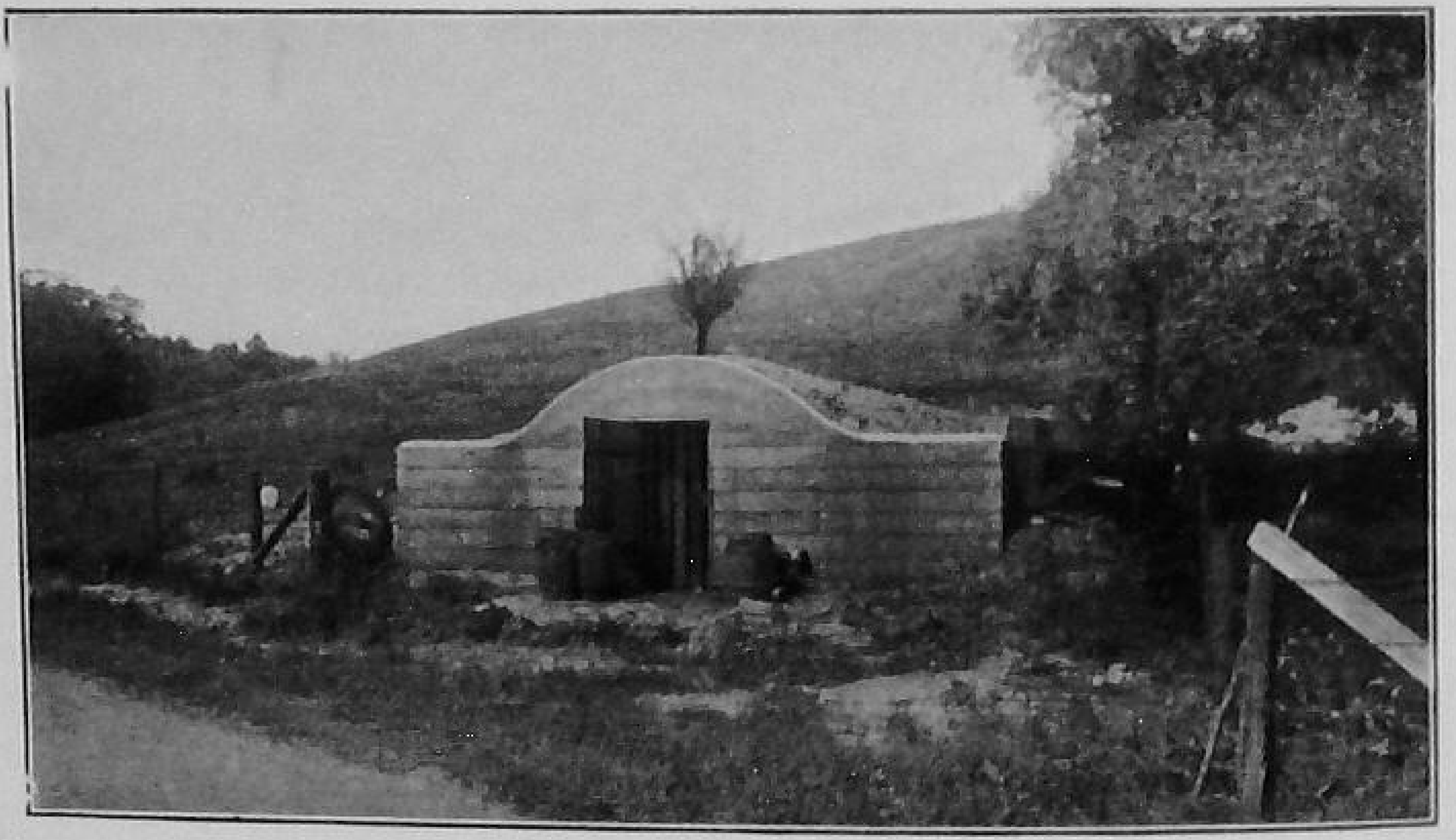

Fig. 28.—A 2- to 3-foot layer of soil serves as insulation to maintain a rather constant temperature in the bank storage cellar. (Boyle.)

Ventilation.—Both temperature and humidity in the non-refrigerated storage may be regulated by ventilation. In bank and above-ground storages, the ventilators and sometimes the doors should be open whenever the outside air temperature is lower than that in the storage except in severe cold weather. Leafy crops, especially celery, respire more rapidly than other kinds, liberating heat, and they also lose water into the air by transpiration. Even in cold storage enough heat will be generated to raise the temperature in the center of the upper crates by several degrees. Wilting and breakdown result, but can be avoided by air circulation and the use of certain types of crates. A fan system is necessary often to equalize the temperature throughout the room. Refrigerator cars are equipped with fans for the same purpose.

Condition of Crop.—Selection of a suitable variety is a necessary step if vegetables are to be held. Some varieties will store or ship better than others. Proper condition of the crop involves the right degree of maturity for the particular vegetable, curing in the case of those which require such treatment, relative freedom from disease or insect injury and careful handling to avoid mechanical injury.

TYPES OF STORAGE.

The place in which vegetables are to be stored will vary with the quantity, the kind, the period of storing and the facilities which can be employed. There are five principal types—artificial refrigeration; above-ground storage houses; below-ground storage; pit, trench or mound in the field; and for the home gardener or consumer, a room in the dwelling cellar. They differ in the ease with which ideal conditions may be maintained.

Cold or refrigerated storage is employed for many crops for short or longer periods. If the installation is adequate in a properly constructed warehouse very accurate control of the temperature is possible. The charges made for refrigeration service differ with the commodity, the temperature conditions desired, the length of the storage period, the size of the containers or volume of space occupied, as well as other considerations.

The *above-ground storage structure* is used in holding sweet potatoes, squash, onions and cabbage. The method of construction differs slightly in each case, since the last-mentioned crop cannot be kept in the dry atmosphere desired for the rest, and sweet potatoes require facilities for warm and humid air while curing. This type might be classified as a low-humidity sort of common storage. The colder the climatic conditions the greater will be the necessity for insulation. It is believed that a house of wooden construction is easier to keep dry than one of brick, stone or cement.

Squash or sweet-potato houses are provided with stoves or other means of heating.

Large central storage houses adjacent to transportation lines are more economical in overhead costs, more easily supervised, and capable of quicker response to market demands than smaller farm storages. In many of the cabbage, onion and sweet potato sections large storage houses are to be found whose owners buy enough of the locally-grown crop to fill their houses.

The *more or less below-ground cellar* is best suited to root storage. Cool, moist conditions are most easily maintained. It may be made of almost any combination of building materials. The south or southeastern side of a hill or bank is the favored location. Some-

times the cellar may be constructed with a door at each end so that teams may pass directly through. When it runs straight into the bank and is completely covered with 2½ feet or more of soil better temperature control is obtained. An earthen floor and the insulating layer of soil have a surprising ability to keep uniform the temperature of the storage. It is often difficult to cool a cellar of this sort in the fall, though opening the doors at night and closing them in the day time will help.

Pits, trenches or mounds of varied styles can be used for storage in the field or garden but their use commercially is decreasing. Temperature and moisture cannot be controlled. Provision is made for ventilation and an increased depth of straw and soil piled on as the weather becomes colder. This method is costly in labor although the space may be unlimited. It is hard to get the vegetables out of these storages. It is often a good scheme to have a number of a smaller size so that the entire contents may be removed whenever one is opened. If the temperature does not drop low enough in November and early December it is almost impossible to keep trenched celery in suitable condition for the holiday trade.

A trench mounded on the sides deep enough to accommodate the celery plants is made wide enough usually for 3 to 8 rows of stalks. Plants with some roots and soil attached are placed therein and boards or tin laid above in the form of a ridge. Straw or leaves and soil are added as needed. Small wooden flues might be stuck up at intervals if the trench is of considerable length. Modifications of this are in use in different sections, some having a temporary pitched roof and a width of 20 feet or more.

Roots can be handled more easily in mounds. A layer of straw is spread out on the surface or in a shallow pit, the carrots, beets, kohlrabi, etc., piled up, covered with a 12-inch layer of straw and a lesser thickness of soil. A little straw sticks through at the peak to serve as a ventilator flue. As freezing weather approaches the soil layer is deepened to about 8 inches, and then manure may be spread over the whole. Cabbage does not need quite as much protection. The heads are cut from the stems and laid in a single layer two or three heads wide and of any length. A shallow trench may be used, and a V-shaped trough inverted over the row. Six inches of soil is banked over the row and strawy manure spread over it. After snow falls another layer of strawy manure is put on the pile. Parsnip and salsify may remain outside in the ground all winter.

The *cellar of the dwelling* will serve as a temporary storage place for vegetables. A room with an insulated partition and some means of ventilation will keep those vegetables for which a cool storage is required. Root crops, and cabbage may be buried in slightly dampened sand. Onions can be hung in slatted crates from the ceiling.

Sweet potatoes, pumpkins and squash should be spread out on shelves somewhere in the balance of the cellar where dryness and a slightly higher temperature can be provided.

Use of Chemicals.—Certain materials such as ethylene are used in storage rooms to speed up the rate of ripening of vegetables. Others like the methyl ester of naphthalene acetic acid can be placed in storages, pits, or cellars to delay sprout development of potatoes, carrots and other root crops. It is possible to spray onions and potatoes with maleic hydrazide before harvest to reduce subsequent sprouting in storage.

Chemicals such as chlorine, pentachloromilamine, tetraiodaethylene, borax and others are used in the wash water in packing sheds to decrease disease losses during transit to terminal markets.

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Chapter 16

MARKETING

The question of marketing is of great importance to the vegetable grower, but because of the large number of methods by which the produce gets from the farmer to the consumer and the various factors involved, the subject is one deserving of study beyond the scope of this book. All that can be done here is to mention a few of the essential principles.

Successful marketing must be the natural sequence to the grower's attempt to reduce his costs of production if he hopes to gain a satisfactory income from his labor.

Direct marketing or retailing may be accomplished by peddling in the town or city, by sales at the curb or farmers' market, at roadside markets, or by parcel-post or express shipments. In these the grower has to take time out from the supervision of production in order to find an outlet for his crop and get it into the hands of the consumer.

Indirect methods of marketing require less personal supervision and are accomplished through wholesale agencies. The producer usually delivers the goods to the shipping point, although the transaction may be through wholesale buyers of various types who come to the farm. Commission merchants, brokers, receivers, jobbers, coöperative organizations and produce auctions are a few of the wholesale agencies. Some are located at the shipping point or have agents there and others are in the terminal markets.

Selling is a service which distributes the produce to the consumer as his needs demand. Charges are made for this service depending upon the functions fulfilled. By far the largest part of this spread between the producer and the consumer goes to the retailer. The return to the producer will be proportionately greater the nearer to the consumer that he carries his product. However, his additional costs for this service must be considered. In periods of high wages, which always cause a high cost of marketing, it is obviously to the advantage of the producer to perform as many of the marketing services as he possibly can. The particular method he chooses for his sales depends upon his location in respect to the market, and the time he desires to devote to the marketing phase.

Preparation of Vegetables for Market.—High quality, uniformity of grade, and an honest pack are points which should be borne in

mind in preparing vegetables for sale. Markets vary in the packages demanded, and it is rather necessary to conform to these demands.

There is some demand from consumers for packaged fresh vegetables which can be selected from the refrigerated display cabinet ready to take home and use just as one would buy groceries off the shelf. Much of the packaging is done at the terminal market rather than at the shipping point. There are many problems involved in this catering to consumers.

FIG. 29.—Uniformity in size and shape adds to the market value of bunched vegetables.

Proper grading becomes increasingly important in the face of greater competition. The cost of grading does not always pay for itself. There are several factors which determine whether one is justified in grading. The distance from market with consequent heavy shipping charges necessitates the elimination of the poorer specimens. This is the reason why the produce shipped to Eastern markets from the West and South is more uniformly graded than much of that grown locally. If the crop is, in general, of high quality, it usually pays to eliminate the culls and those of second grade. However, if the quality of the whole lot is low, the expense of grading will not be repaid. Ordinarily, on a slow market, the premium

for the graded goods is higher than on a fast market although the actual price received may not be so great.

Standard grades have been promulgated by the United States Department of Agriculture for interstate shipments. In general these have been accepted by the states, and a system of shipping-point

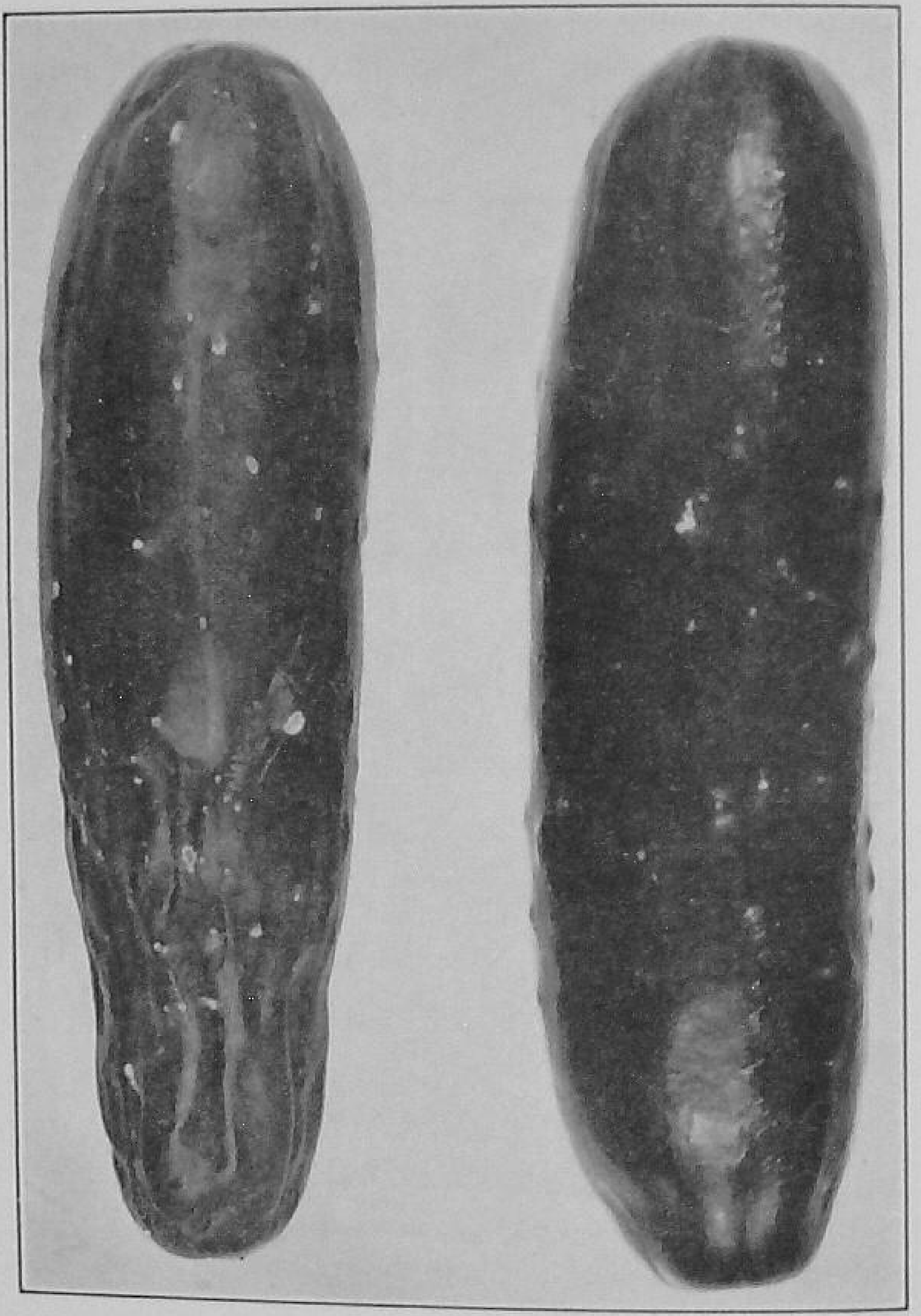

FIG. 30.—Waxing of the cucumber on the right has retarded shrivelling and loss of the dark green color during 10 days' storage at 73° F. at a relative humidity of 44 per cent. (Courtesy Cornell Univ. Agr. Exp. Sta.)

inspections set up coöperatively by the Federal Government and the various states. The shipper pays a small charge to cover this service.

Information concerning standard grades can be obtained by application to State Bureaus of Markets or the Federal Bureau of Agricultural Economics.

When a shipment has been certified as to grade at the shipping point the buyer at the terminal market knows what the car should

look like when he receives and opens it. Thus a fair basis for the sale is furnished, danger of rejection is lessened, and the shipper has evidence as to the condition of the produce when it left his hands.

While this system of official grades applies primarily to car-lot shipments, yet the local grower can well afford to be guided by these standards in preparing his vegetables for market. He will have to compete frequently with such graded produce from a distant shipping point and from the point of view of the buyer or consumer the pack which is uniform throughout is the best.

Many canning factories are buying their raw product on the basis of the official grades. This practice is mutually profitable to the grower and canner alike.

Waxing.—Since the principal cause of shrinkage and wilting of vegetables after harvest is the loss of water into the atmosphere, a thin coating of wax serves to retard this loss. This practice is particularly important for vegetables shipped long distances, or for those likely to be held in retail stores for several days. Vegetables may be dipped a moment in the wax emulsion, allowed to drain, and then dried rapidly. Cucumber, eggplant, pepper, summer and winter squash and pumpkin, tomato and all the topped root crops except parsnip can profitably be waxed. Root crops, especially rutabagas, are, in certain sections, coated by being dipped momentarily in melted paraffin. Naturally, the waxing process does not improve the quality of a low grade vegetable. It merely assists in maintaining the quality of high grade vegetables. In addition to use as an emulsion the special waxes can be applied as hot wax or dissolved in a solvent which evaporates quickly.

Marketing the Garden Surplus.—The farm garden may become a source of cash income for the family if the yields are greater than the members of the group can consume. This surplus can be disposed of by sales to neighbors, or by sale at a roadside market. Since roadside selling may lead to enlargement of the garden operations it seems desirable to point out a few of the factors which appear to be of importance in successful roadside marketing.

A location on an improved highway near centers of population is a valuable aid to success. It is usually not the transient automobilist who is the reliable client of the successful roadside seller, but rather the inhabitant of the city or town who drives out regularly for the air and beauty of the country as well as a supply of fresh produce. Stands on the right-hand side of the highway leading into the city are considered to be more successful. Adequate parking space is essential.

A neat and attractive stand or sales booth should be provided. At first a continuous and adequate supply of vegetables may not be available as would be the case of the market grower who defi-

nitely plans his operations to furnish such a supply. Yet if the garden is properly planned to give the family a succession of crops this requirement will be met in some measure. It is possible also to coöperate with neighbors by pooling the surplus of several gardens. On a larger scale this matter of supply is of paramount importance, and a careful study of sales records will indicate the crops that need amplification. One is not justified in trying to build up the business with vegetables purchased in the city and brought out into the country. Under certain conditions an out-of-season demand, if consistent, may have to be met in this way. Such products should be labeled accordingly. Deception is not profitable.

The vegetables offered should be of the highest quality, attractively displayed, and kept in as fresh a condition as possible by shading and watering, where this is necessary. Price tags should be in evidence, and the prices marked thereon should be fair. Sometimes these prices may be above, at others below, the current retail price in the city. It depends quite largely on the quality of the product, the demand in relation to the supply at that season and the reaction of the customer. If the buyers appear consistently to feel that a particular price is too high it is well to adjust it accordingly. In general a price level intermediate between the wholesale and retail values will be about right.

It seems scarcely necessary to mention the importance of courteous salesmanship, personal cleanliness on the part of the salesman, neat signs and advertising. Packages, bags or boxes of various capacity should be on hand to fit the needs of different sized families. Trade marks or other forms of advertising on these containers are used by progressive roadside markets.

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Part II. Cool Season Crops

Chapter 17

THE PERENNIALS

These crops are able to withstand winter conditions, although with certain ones and in some climates additional protection is advisable. When grown in the home garden they should be planted in a location to one side of the main area so that they will not interfere with future preparation of the land for planting of annual crops.

ARTICHOKE, GLOBE.

(Cynara scolymus.)

This crop which resembles the common thistle is a native of North Africa and has been known to the epicurean for well onto 2000 years. The Globe or Burr artichoke has not gained the wide use here that it has abroad. California is the producing center for the market crop, although it is grown to some extent in the Gulf and South Atlantic States.

It is possible to grow the crop as a novelty in other parts of the country if the plants are given winter protection. Commercially no such protection is given because of the proper climate.

Fertilization.—A fertile soil is desirable. Manure at the rate of 10 to 20 tons per acre can be worked into the soil yearly between the rows as the new growth starts, and a sidedressing of 60 to 100 pounds of nitrogen to the acre made in a single application in late summer or split with the second fraction being worked into the soil just as the buds begin to form in early fall. In the East a complete fertilizer supplying that much nitrogen would be desirable as a spring application.

Propagation and Culture.—The artichoke does not come true from seed but can be started that way if off-shoots are not available. Plants are grown in containers and set in the field. On a small scale in marginal climate areas the plants can be spaced 3 to 4 feet in rows 4 to 5 feet apart. In the commercial plantings the rows are about 8 feet apart and the plants spaced 6 feet in the row.

Shoots arise from the stump of the old fruiting stalk which was cut off when its buds had been harvested. Each shoot in turn pro-

duces a stalk with buds. The plant thus spreads out. After four to seven years of production, 8 to 10 inches of the rootstock of the old stalk is lifted and reset with the top about level with the soil surface in a new field. This method of propagation may be surer of success

Fig. 31.—Each one of these new shoots arising from the base of the previous year's flower stem will produce a stem bearing a crop of artichoke buds. (Courtesy California Agr. Ext. Service.)

than the transplanting of a shoot with but a fragment of attached root. Irrigation should promptly follow the setting of the rootstocks.

The bed should be kept free from weeds to avoid competition for moisture. The artichoke is a deep-rooted plant but will need to be

irrigated whenever the root zone begins to dry out. A lack of water is likely to cause loose buds, as will hot dry weather.

Varieties.—The Green Globe is more popular than the Purple.

Harvesting.—Plants grown from seed seldom produce buds the first year. Besides giving greater uniformity in productivity, the gain of a year makes vegetative propagation preferable. The edible part consists of the globular flower buds produced on an upright fruiting stalk. The bases of the bracts of this bud are thick and fleshy and with the solid center of the bud are all that one eats. The stem is cut about an inch below the bud when it has attained a diameter of 2 to 4 inches but before the bracts begin to separate. The time of harvest in the North is July. Yields of 18 buds per plant have been reported. California growers have found that the mild winter and cool moist climate have favored the practice of fall, winter and spring harvest. In April or May the tops are cut off 3 to 4 inches below the surface of the ground with a slanting knife, either stationary or rotating. If a furrow is plowed away from the plants on each side of the row the cutting of the tops is made easier. The debris can be buried between the rows, used as ensilage, or burned. Irrigation given after six to eight weeks' rest stimulates growth. The tops develop during the summer months and harvests begin in early fall, continuing until the next April. The buds are cut off once a week or less often in cold weather. Yields in California average about 2 tons of buds per acre. The buds are graded and packed according to size.

Protection.—The root stocks will survive temperatures considerably below freezing if given some protection. Late in November in localities subject to freezing the tops are cut off 12 inches from the ground and gathered about the crown. A foot of coal ashes is placed over the plant. This is removed in March or April and new growth soon arises from the root stalk. Manure is unsatisfactory as a protecting medium as its use seems to favor a rotting of the crown.

Insects.—Under commercial conditions in California parathion has given fairly good control of *Aphids* and of the *Plume Moth*, the larvae of which tunnel through the buds.

ASPARAGUS.

(Asparagus officinalis.)

A native of Europe and Siberia, asparagus has been cultivated for over 2000 years. It was valued by the Romans as a medicine and food. Its introduction to the United States dates from early Colonial times. When grown in Florida and Louisiana asparagus yields poorly owing to insufficient storage of food reserves in the roots during the summer months.

Once a plantation has been established it will continue to produce profitable crops for ten years or more. A well-drained sandy loam or sandy soil is preferred because of increased earliness. Silt soils are better than heavier soils for the crop grown for canning or freezing as they are easy to manage and do not produce as many crooked spears. Soils which are mixtures of silt and peat are used in California for the white asparagus grown for canning.

Proper preparation of the field is important. It should be plowed deeply. Fallowing with frequent harrowing or the use of herbicidal sprays will get rid of many weeds the season before the crowns are to be planted. Organic matter can be added to the soil by turning under a soil-improving crop instead of fallowing. Sufficient lime should be plowed into the soil to bring the soil reaction close to the neutral point. If the land is low in phosphoric acid and potash, heavy applications of these should be plowed in deeply as future applications will not move far into the soil, and cannot be drilled in to much depth after the first few years because of possible root injury.

Another way of accomplishing this preplanting fertilization is to make the furrows deeper than normal. The fertilizer is then worked into the bottom of the furrow. Several inches of soil are replaced before the crowns are planted. Up to a ton of limestone can be put with this fertilizer if soil acidity needs correction. Dolomitic limestone has been found desirable on soils lacking magnesium.

Fertilization.—An attempt should be made to incorporate a good amount of organic material before the crowns are placed. The decay of the old roots and the disking under of the old tops have been thought to furnish enough organic matter once the bed is started. Yet many find that applications of 10 to 20 tons of manure an acre have been helpful. Fresh manure adds weed seeds so rotted manure or poultry manure are suggested by some. Manure should be broadcast in the fall or winter and disked under in early spring when the soil above the plantation is worked into a fine condition. Some growers have been fairly successful with green manures seeded between the rows late in the summer after the tops have made a thrifty growth. Thus injurious effects of competition for water and minerals between the asparagus and the green manure crop are minimized. A legume or cereal crop which will winter-kill seems to offer the greatest possibilities.

Most of the material from which the shoots are formed in the spring is stored in the fleshy roots of the crown during the previous summer and fall. Thus the aim is to produce a heavy top growth after the cutting season is over and allow the tops to remain undisturbed until frost when the food in them will have moved downward. In the spring, the old tops are disked into the soil along with

the fertilizer, which on sandy soils should supply 50 to 100 pounds of nitrogen and 125 to 175 pounds each of phosphoric acid and potash. This might be 1500 pounds of a 5:10:10 analysis. Less potash in relation to phosphoric acid is required on heavier soils. The fertilizer may be given half before and half after the harvest season but in general, it is preferable to apply all the complete fertilizer in the spring. It can be worked into the soil easily at that time and the phosphorus and potash are available when top growth is permitted to develop. An application of these two nutrients made after the cutting season may not become available to the roots owing to dry weather. It is well to top-dress the area with 30 to 40 pounds of nitrogen per acre in a readily soluble form as soon as harvesting terminates. If rains do not come to carry this nitrogen to the roots it may be desirable to use sprinkler irrigation.

Salt (sodium chloride) has little or no effect as a fertilizing material. Chlorine is furnished by muriate of potash and sodium as nitrate of soda. For effective weed control rather excessive amounts of salt are necessary.

Propagation and Culture.—Asparagus seed germinates more quickly if it is soaked first at 86° to 95° F. for four to five days and then drilled into a moist rich soil at a depth of 1½ to 2 inches. Planting of the seed is done in early spring. The rows should be 18 to 24 inches apart. If too much seed is used the crowns will be small and so intertwined as to be difficult to separate. The plants in the nursery should stand at about 3 inch intervals. Precision planting is desirable. Usually 5 pounds of seed to an acre of nursery will give the proper stand of plants. More seed is used if there is danger of loss of seedlings from soil fungi. This area should furnish enough good crowns to set out 10 or more acres according to the field spacing used.

A pre-emergence oil spray will aid in weed control. Thereafter shallow cultivation may be needed to keep the nursery free of weeds. The crowns are allowed to develop for one season. It is best to leave the crowns in the ground until it is time to lift them for field setting in the spring which may be from January to April depending on climatic conditions. Unless many roots are desired it is perhaps best to buy them from a good grower.

Select large, well-grown, one-year-old crowns that have not been crowded in the seedling row. They must not be allowed to wither or to heat. These two conditions are common causes of poor stands. The crown consists of absorbing and storage roots. It is difficult to dig out two-year-old crowns without severe injury to the storage roots which will reduce the yields for several years. In sections where the plants bloom the first year it is possible to select the staminate or male plants. These will out-yield the female crowns.

However commercial growers do not bother about the sex of the crowns. Breeding techniques have been developed for the production of 100 per cent male populations. They have not come into general use.

Furrows are opened 8 to 10 inches deep in sandy loam soils or slightly less in heavy soils. Usually 4 to 6 feet are allowed between rows and even 8 feet if the soil is to be ridged up for the production of white or blanched "grass" for utilization in canning. A crown is dropped every 18 to 24 inches, sometimes every 12 inches, the roots spread out and the whole covered with 2 to 3 inches of soil. As cultivation is practised to kill weeds more soil is worked in about

FIG. 32.–One year old asparagus crowns are used for starting a new bed. The asparagus roots on the right will make weak plants.

the shoots. This also buries any weeds which have started in the row. By fall the furrow is filled. If this were done at the time of planting the small shoots would have been smothered. Machines have been designed for planting the crowns and covering them with a shallow layer of soil. A spacing of 12 inches gives more producing units to a given area so the harvest of spears will be increased during the first four or five years. The life of the bed will still be satisfactory.

Direct seeding of asparagus without the necessity of planting crowns has been practiced in California and other areas. Furrows are opened on 4 to 6 foot centers. These can be made about 6 inches deep. The seed is drilled in the bottom of the furrow at the rate of 1½ pounds per acre. This gives a plant every 3 to 4 inches. As the seedlings grow the furrows are gradually filled. Another

method is to drill the seed well down in the shoulders on each side of a deeper furrow. By the end of the first season the soil is ridged slightly over what was the furrow, giving double-row beds on 5½ or 6 foot centers. The advantage of this direct seeding method is that the yields during the first few years will be much greater than by the conventional method.

Low-growing vegetables may be planted as intercrops between the asparagus rows to offset the first year's cost of the plantation. Snap beans, lettuce and cabbage have been used.

An established bed must be disked thoroughly in early spring before any shoots appear. This works in the manure, the old tops and also the fertilizer. In spite of this, there are usually some weeds to kill at the close of the cutting season. This is accomplished most easily by use of an extension disk straddling the rows, and followed crosswise by a spike or spring-tooth harrow. Some few shoots are destroyed. In well-established beds, care must be taken that the disk does not cut into the crown as this will decrease subsequent shoot growth. Light cultivation between the rows with a spike-tooth harrow set shallow will help check weed growth during the cutting season. When the tops are allowed to grow cultivation must continue or weeds will overrun the crop. Cyanamid spread over the row in a strip 18 to 24 inches wide at the acre rate of 250 pounds on light soils and 350 to 500 pounds on heavier soils is helpful in weed control. Since it furnishes nitrogen, the analysis of the mixed fertilizer should be such as to supply proportionately less nitrogen. Flaming, and 2, 4-D or oil sprays are other means of controlling weeds before and after the cutting season. If directed carefully at the base of the stems, they can even be used during the summer period of fern growth.

After the beds are worked up in the spring Crag herbicide 1 can be sprayed on the surface at the rate per acre of 2½ to 3 pounds in 30 gallons of water. Karmex W at about 2 pounds per acre on light soil and 3 pounds on heavy soil in 50 to 100 gallons of water has been effective also. A rain following application is helpful. If these materials are sprayed over the rows only then proportionately lighter rates are used. Crag herbicide 1 can be used again at the end of the cutting season but too much Karmex W may cause a toxic condition.

When white asparagus is to be produced the soil over the row is disked to kill weeds and made fine. The ridge is then rebuilt to a height of 10 to 12 inches above the crown. This must be done every eighteen to twenty-one days as the cutting knocks down the ridge.

Irrigation.—Asparagus is a deep-rooted crop. However where rainfall is scanty or lacking during the summer months when the fern is developing, it may be necessary to irrigate once or twice in

order to keep available moisture in the root zone. Enough water should be applied to fill the soil reservoir to a depth of 8 to 10 feet. Subirrigation is practised in many of the asparagus fields in the Delta region of California. Sometimes the crop is irrigated during the cutting season.

It is quite common in California to flood older asparagus fields for three or four weeks during December or January. Levees are thrown up around a field and the area kept covered with about 12

FIG. 33.–Cutting and picking up blanched asparagus in the Delta region of California. (Courtesy California Agr. Ext. Service.)

inches of water. This is an effective method of controlling the garden centipede which is a serious pest, and the flooding causes the spears to develop ten to fourteen days sooner than if the plantation had not been flooded. Harvesting of flooded fields should cease a couple of weeks sooner than in non-flooded areas.

Varieties.–The most desirable variety is Mary Washington, which produces very uniform large-sized shoots, dark green in color with a slight purple tint. The buds and leaf scales at the apex remain compactly together. Mary Washington 500, a strain developed in

California, is a very high-yielding one that is becoming popular in many parts of the world.

Harvesting and Bunching.—The first cuttings may be made the second spring after the crowns are set out, that is, after two full seasons' growth. The first harvesting should not be prolonged more than two to three weeks. If the plantation is not especially vigorous it may be well to wait until the third year before any harvest is taken. The cutting season is lengthened until, after two years, harvesting may last a full eight weeks. If cutting is prolonged especially in a dry spring, the yield in the succeeding years will be reduced.

In California the beds are cut three or four weeks in the spring following the first summer's growth of the new bed. The next year the cutting is prolonged to eight to ten weeks and to the normal twelve weeks in succeeding years.

It is necessary to cut daily, if the weather is warm, and preferably in the morning. A special asparagus knife is used. While one hand grasps the top of the shoot, the knife is run down the side of the shoot and by tilting slightly a single motion severs the spear about 1½ inches below the surface. Care must be taken to avoid cutting other shoots or the buds on the crown. Snapping of asparagus spears destined for processing has been tried in some areas in place of the conventional cutting method.

Green "grass" is cut when the shoots are 7 to 9 inches above the ground. White "grass" must be harvested as soon as the tips appear through the ridges. This latter type of product requires that the severing of the shoot take place 6 to 7 inches below ground. A machine has been developed that harvests green spears, picks them up, and places them in crates. Mechanical harvesting of blanched asparagus is more difficult because of the depth at which the spears must be cut.

Cut asparagus should be shaded to reduce wilting and moved to the packing room as quickly as possible. The sooner it is used the better will be the quality. The spears are graded for size according to diameter. Badly crooked spears resulting from mechanical or insect injury are discarded.

The various categories are made separately into 1, 2, or 2½ pound bunches. A clamp-like device aids in getting the proper size of bunch. Raffia, or tape is tied around the top and bottom of each bunch. Sometimes different colors of tape distinguish the various grades. The butts are cut off squarely so the bunches will stand upright in a tray of cold water until packed. The length of the trimmed spears is usually 9 inches but varies from about 7 to over 10 inches in different districts. Normally the greater the proportion of the stalk that is green the better will be the price.

A two-compartment pyramidal crate is filled with a dozen bunches all of the same grade. Each bunch may be wrapped in parchment

paper to carry advertising material. Instead of bunches, a pyramid crate may be filled with spears of uniform diameter. This is known as a loose pack. In any case the bottom of the crate has a pad of wet material such as sphagnum moss on which the butts rest. An inch or so of clearance is allowed at the top of the crate to permit elongation of the spears during the marketing period. Asparagus should be held as close to 32° F. as possible to reduce elongation and deterioration in quality.

Yields of plantations in full harvest will average between 3000 and 5000 pounds an acre each year.

Insects and Diseases.—The *Asparagus Beetle* may become a serious cause of reduced yields. The dark gray, soft-bodied larvae and the blue-black beetles, somewhat less than ½ inch in size, with red and lemon-yellow markings, both feed voraciously on the foliage. The treatment consists of cutting all shoots, even the unmarketable ones, during the harvest period; using a .75 to 1 per cent rotenone dust or equivalent spray on the young spears; leaving a few as trap plants coated with calcium arsenate dust; dusting the tops with calcium arsenate or 5 to 10 per cent DDT dust during the summer.

Asparagus rust is controlled by the use of a rust-resistant variety such as Mary Washington. Burning the dry fern after it is removed in the fall will help in rust and beetle control.

The gradual deterioration in yield of asparagus plantings after about ten years and the lack of success in replanting asparagus soon after an old plantation is removed are thought to be due to a species of Fusarium. Disease-resistant varieties must be developed.

RHUBARB.

(Rheum rhaponticum.)

The roots of this plant have been employed as a medicine for ages by the peoples of its native habitat, Siberia. At present the fleshy petioles are used in sauces and pies, hence the rather common name—pieplant. The rhizomes and crowns are quite resistant to cold and drying. They become dormant in winter in the North and withstand freezing. Rhubarb does not do well in most parts of the South. In sections of California where the summers are dry and the winters mild, the plants are dormant in the summer.

Root activity starts at low temperatures and results in the appearance of rhubarb on the market rather early in the spring. It is in greatest demand at that time. Low temperatures favor the development of a good pink color in the stalks.

Fertilization.—An abundant supply of nutrients and moisture are essential. Therefore a deep rich sandy loam is preferred. Rhubarb

is tolerant of soil acidity but does best at a reaction of pH 5.5 to 7.0. If the soil is not fertile it should be improved with manure and cover crops before the plantation is started. A southern exposure where snow and ice melt early is desirable.

Applications of about 20 tons of stable manure an acre appear satisfactory. The material is applied in the fall or winter and worked into the soil the next spring. When used as a mulch it is thought the soil freezes to less depth, thus the roots start activity sooner in the spring. The mulch is raked into the spaces between plants as soon as hard freezes are over. It is well to supplement the manure in the spring with 50 to 80 pounds each of nitrogen, phosphoric acid and potash per acre.

Commercial fertilizer must be used if manure is unavailable. The analysis should be adapted to the class of soil and its state of fertility. About 100 pounds of nitrogen and 150 to 200 pounds each of phosphoric acid and potash to the acre are suitable for sandy soils. The fertilizer is harrowed into the soil when the bed is worked before growth starts in the spring. Since the spring growth is largely from stored food in the rhizomes, the nitrogen is likely to give greatest results if some is applied at the end of the cutting season so that it may function in stimulating a good foliage growth for the summer. At that time, an additional 40 to 50 pounds of nitrogen per acre should be broadcast.

Propagation and Culture.—The only excuse for the use of seed in the propagation of rhubarb is an attempt to develop new varieties. The open pollenization results in such mixtures that there is no uniformity in the plants.

Division of crowns obtained from plantations free of crown rot is the better method. Each piece should have at least one good bud and some of the fleshy rhizomes containing stored food. Propagation is practised while the crowns are dormant. In the North the new bed is set in the early spring but in milder sections the fall months are considered a better time. The crown segments are placed in spaded holes or in furrows with their tops a few inches below the ground level. The plants can be spaced 3 to 4 feet in rows 4 to 6 feet apart depending on the machinery used for weed control, and on the method of irrigation.

Flower stalks which will develop to a height of 4 to 6 feet appear late in the spring on a considerable number of the plants. Obviously these should be cut off as soon as noticed since the formation of this tissue constitutes a serious drain on the storage supplies.

After four or five years the plants may drop off in yield or produce more small-sized petioles. A crowding of the roots is believed to be a contributing cause. The crowns may be dug out, some saved for replanting and the rest forced. If this method of renewal

is employed, a part of the bed may be set out each year so that a succession of new crowns for harvest is provided.

The root system of rhubarb extends in the soil 3 or 4 feet laterally and to considerable depth filling the surface layer with fine absorbing roots. Cultivation should be shallow and frequent enough to remove the possibility of weed competition. Water should be

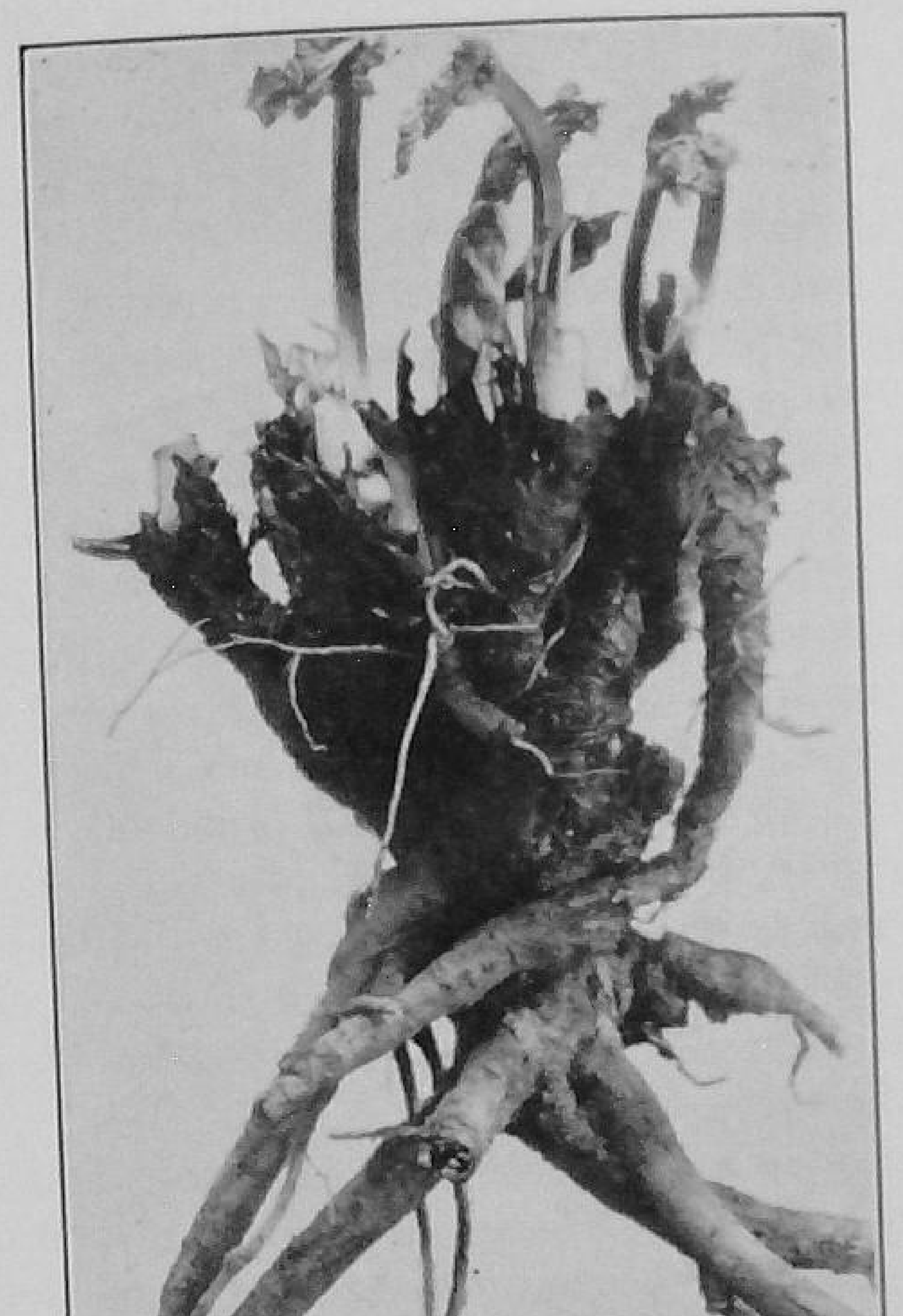

FIG. 34.—Fleshy rhizomes comprise much of the underground portion of the rhubarb plant. (Courtesy California Agr. Exp. Sta.)

supplied by irrigation when the soil becomes dry. This will maintain the top growth which in turn stores food in the rhizomes from which the next season's crop is developed.

Varieties.—The Victoria is very vigorous with a stocky though somewhat green petiole. Linnaeus produces small, tender leafstalks of a good pink color. MacDonald has very red petioles. Crimson Winter and Cherry are popular in the West.

Harvesting.—In the spring following the second full season of growth a harvest of four to five weeks' duration is permissible. In later years this may be extended to eight weeks if the size of petiole continues satisfactory. At no time should all the leaves of a crown be removed. The stalks are pulled out and not cut. By grasping the petiole near its base and pulling, with a slight twist, in the direction of growth, it may be separated without leaving a stub to decay.

The leaf-blade should be severed at once, leaving 1 to 2 inches of the mid-ribs with intervening tissue. Thus wilting of the petiole is reduced. On some markets the rhubarb stalks are sold loose, while others require that they be sorted according to length and several tied together with tape at the top and bottom. An acre should yield 2 tons of stalks, or 20,000 stalks.

Forcing.—Specially grown two- to three-year-old crowns or those remaining after enough have been reserved for the spring planting of a new bed may be forced in any darkened place where the temperature stays about 55° to 60° F. The crowns may be dug before the ground freezes, sorted and those to be forced moved near the buildings. A rest period of six to eight weeks is needed in order to get the greatest yields. This rest of the dormant roots is easily broken by freezing and results in more rapid growth when heat and moisture are supplied. Frozen crowns may be handled with less breakage of the fleshy rhizomes. A corner of the cellar, a hotbed, the space beneath a greenhouse bench or a special forcing shed can be used.

Soil or fine ashes are placed in a shallow layer to hold moisture. The crowns are packed closely together, the spaces filled and the surface covered with soil or other moisture-holding material. The whole mass is watered thoroughly. It may be necessary to apply more moisture from time to time as forced rhubarb is composed of over 95 per cent water.

The first harvest will be ready in four to five weeks. Forced rhubarb is very tender, slightly acid and of a delicate pink color. In the dark the yellow leaf-blade seldom develops to hand-size and is allowed to remain. This feature adds attractiveness to the product and identifies it as forced rhubarb. The stalks are pulled in the same manner as the outdoor crop. A continuous harvest is obtained by starting a new lot of roots every three or four weeks.

If the intention is to use the forced crowns for resetting in the field not all of the stored food should be exhausted. The partly depleted crowns may be placed outdoors, allowed to freeze and be reset in the spring. They should not be forced again for several seasons.

The growth of rhubarb crowns in the field may be hastened by the use of forcing boxes. This is possible likewise with asparagus. The box is a miniature coldframe of such size that a sheet of glass may be used for the top. Fermenting manure is packed around the box which has been placed over a rhubarb crown. This is done in early spring on a day when the frost is about out of the ground. The heat on sunny days starts the buds into growth, and makes a harvest possible several weeks ahead of the normal first pulling.

Diseases.—Crown Rot is a serious cause of loss in rhubarb plantations. Selection of crowns for propagation from disease-free fields and removal of infected plants are recommended.

SEA KALE.

(Crambe maritima.)

The succulent leaf-stalks arising from the plants in the spring constitute the edible part of this crop. Sea kale is more popular in England than in this country. It is one of the earliest products available in the garden, and as it precedes asparagus is useful as a substitute for that crop.

Fertilization.—The plants are cared for in a manner similar to rhubarb. A deep, rich soil is desirable. A manure mulch is placed in the fall. Chemical fertilizers are occasionally justified to promote a strong top growth.

Propagation and Culture.—Seeds or root cuttings are the means of starting new beds. Seed is sown about 1 inch deep in rows 12 to 18 inches apart. The seedlings are thinned to 5 or 6 inches in the row. They may be started under glass. Weeds are controlled during the growing season and the plants mulched with manure in the autumn.

The following spring the best plants are given an early transplanting to their permanent location with a 3 by 3 foot spacing.

Root cuttings 4 or 6 inches in length may be made from the side branches of roots in an old bed, or those which have been dug out for winter forcing. Cuttings made in the fall can be stored in sand until spring.

As with rhubarb, the flower stalks should be removed as soon as they appear, except when seed is desired.

Blanching and Harvesting.—Two years after the permanent planting is made a short harvest may be taken. The third year the shoots can be cut safely for three weeks or more.

The crowns are covered with loose litter, loose soil, small kegs, or large clay pots with the drainage hole plugged. The leaf-stalks develop with little pigment and an absence of any bitter flavor.

When they reach a height of 6 to 8 inches they are cut with a regular asparagus knife. After the short spring harvest, development of the tops is permitted to store materials in the roots for the following spring. Lily White is the most popular variety.

Fig. 35.—The blanched succulent leaf-stalks of sea kale may be harvested for a short while in early spring. (*The Country Gentleman.*)

SORREL AND SPINACH DOCK.

(*Rumex acetosa and R. patientia.*)

Both of these crops belong to the genus Rumex and are similar in their cultural requirements. The harvested leaves are sold as "sour grass."

The light green, long-stalked leaves of the garden sorrel are more or less lobed at their base in a manner similar to the native wild sorrel. Large Belleville and Narrow Leaved are the garden sorrel varieties most commonly listed by seedsmen.

The spinach dock has thicker, taller growing foliage without the basal lobes. Years ago these perennials were common in gardens and merit a place even now because of their very early production of "greens."

The land is thoroughly prepared and marked out in the fall. Manure at the rate of 20 to 30 tons an acre is used in the preparation of the ground. Seed can be sown on the frozen ground in January or later in early spring. A common method is to sow the seed in double rows 8 inches apart with an 18-inch space between pairs. The plants are nitrated rather heavily, and grow rapidly, so that cutting may begin by May first.

With irrigation and side dressing of nitrate sufficient bulk is obtained to permit harvesting every two weeks during good growing-weather. In cutting the top, an inch or more of stem is left. Thus the center buds are uninjured and new growth arises. The beds are kept in production two or three years before renewal.

FIG. 36.—Harvesting spinach dock. (Courtesy of the New Jersey Experiment Station.)

Seeding in July, August or September and winter mulching with well-rotted manure will bring on an earlier spring harvest. Cold-frames are used to force growth for the winter market.

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Chapter 18

POTHERBS OR GREENS

SINCE early times foliage plants have been served cooked as "greens." Wild and cultivated forms have been used, and even now the first spring growth of many herbs finds its way into the pot. For the cultivated kinds, good soil conditions with sufficient readily available nitrogen are conducive to rapid growth of succulent tender tissue.

CHARD OR SWISS CHARD.

(Beta vulgaris var. cicla.)

This was the beta of the ancients more than two thousand years ago, and is a beet in which the foliage parts make greatest growth rather than the root. The leaf-blades replace spinach. It is normally a biennial.

Fertilization.—A rich soil well supplied with humus is desirable. If the soil is not rich in organic matter this should be added as barnyard manure or green manures. This crop will usually show a response on sandy soils to fertilization with 50 to 100 pounds per acre of the three principal nutrients supplied in a 1:1:1 ratio. On silt soils, a 1:2:1 ratio furnishing at least 50 pounds of nitrogen is justified. A smaller quantity of fertilizer will do if manure is applied. Side dressings of nitrate should be given to maintain a steady growth.

Propagation and Culture.—To produce an early harvest, the seed may be started under glass 6 to 8 weeks ahead of field planting, the seedlings pricked out, hardened and set in the field after severe freezes are over. Outdoor seedings in early spring can be made in rows 18 or more inches apart. The seeds are really fruits so several plants may arise at a place. Thinning may be done in one operation, or if desired, by successive stages to 3, 6 and 12 inches, the thinnings being used for food.

Chard does well through the long warm days of summer, and where winters are mild, plants may be carried over until spring but will produce a seedstalk as a result of the exposure to cool temperatures.

The root system is vigorous and quite thoroughly distributed well up to the surface. Weeds must not be allowed to compete with

these roots. Shallow cultivation appears desirable. Irrigation should be given often enough to maintain available water in the top 3 or 4 feet of soil.

Varieties.—Stocks appear to be rather mixed and considerable variation exists within a single variety. There are three more or less distinct types that are commonly grown.

1. Light green, much crumpled leaves with light green narrow petioles. Plants rather erect. Lucullus, a variety long in use, is of this type.

2. Medium green, smooth to slightly crumpled leaves with broad white petioles. Plants medium size and spreading. The Silver Leaf has these characteristics.

FIG. 37.—The dark green, savoyed growth of Fordhook Giant Swiss chard is quite different from Lucullus (center) and Silver Leaf (left).

3. Dark green, much crumpled leaf-blade with broad white petioles. Plants very vigorous and erect. Fordhook Giant is a desirable variety of this description.

In addition to these there is the Rhubarb variety with red petioles.

Harvesting.—The leaves are cut from the plant, before they begin to turn yellow, by severing the petiole near its base with a sharp knife. New leaves are produced from the center. Several harvests can be made provided the growing point is not injured as the top growth is cut off. On some markets the leaves are sold loose while for others they must be tied in bunches of about a pound in weight. The whole plants can be pulled or cut off just above the soil when they are a foot or less in height. The plants may be bunched or sold loose. An acre yields about 5 tons.

Insects and Diseases.—The *Beet Leafminer* is perhaps the worst pest. It attacks the plants in early summer. Beet, spinach and lamb's quarter also fall prey to its ravages. When the eggs hatch

the maggots burrow in between the upper and lower epidermis of the leaf where they cannot be reached by sprays or dusts. A blistered area is the first indication of their presence. The white larvae about 1/5 inch in length feed on the internal tissues. Cleaning up refuse, and destruction of lamb's quarter are recommended. Liberal fertilization will enable the chard to outgrow the attack and while some of the leaves must be discarded, a new supply will be ready soon. If the presence of leafminers is observed soon enough a TEPP spray might aid in control.

CHICORY.

(Chicorium intybus)

The cut-leaved type of chicory is grown much the same as dandelion. This Cicoria di Catalogna is known on certain markets as radichetta, or often as asparagus or sprouting chicory. The latter name derives from the young flower stalks with a faint asparagus flavor that are produced by some strains.

DANDELION.

(Taraxacum officinale.)

The name appears to be a corruption of the Italian *Dente di leone*, or lion's tooth. Dandelion is treated as an annual, although when undisturbed it is biennial or perennial in its flowering habit.

A light sandy soil to speed early spring growth, but of sufficient richness to produce a good storage root is desirable. Normally the dandelion utilizes the fertilizer residues of the spring crop that it follows. If the soil is not very productive 5 tons of poultry manure supplemented with 100 pounds of phosphoric acid, or else a complete fertilizer of a 1:1:1 or 1:2:1 ratio at a rate to supply 40 to 50 pounds of nitrogen should be worked into the soil ahead of planting. A side dressing of about that much nitrogen may be given in early fall and again in early spring to hasten growth and improve the size and succulence of the leaves.

Propagation and Culture.—Dandelion is seeded in August or somewhat later in areas with a mild winter climate. The rows are best spaced at 18 inches unless two-row beds on 40- or 42-inch centers are used. In such case they can be 14 to 16 inches apart. Irrigation can be very beneficial in getting a stand of plants when seeding is done under hot dry conditions. A satisfactory variety is Arlington Thick Leaf.

Harvesting.—The plants are allowed to store food all season in preparation for an early spring crop. As soon as the early spring growth starts the harvest is made by cutting the whole plant. The

rosette of leaves should be dense and 12 to 20 inches across. An acre will yield 800 bushels. Dandelion tops may be blanched like endive by tying up the leaves, or by covering with a pot or other material.

The roots may be dug in the fall, stored and forced during the winter in a warm place.

When the harvest is finished the land should be plowed to prevent the old roots and cull plants from becoming troublesome weeds.

MUSTARD.

(Brassica juncea, B. hirta and B perviridis.)

A number of species of mustard have been cultivated in various parts of the world since Biblical days. In the United States mustard is found more commonly in parts of the South. It requires a rich moist soil and cool weather. Elongation of the flowering stalk occurs rather quickly when the days become long. Thus the crop is limited to spring, fall and winter harvesting, although it may be possible under some conditions to have mustard greens all season by successive plantings and irrigation.

Propagation and Culture.—Seed is sown very early in the spring or in August in the North, while in the southern areas planting can continue from August until mid-winter. The rows are spaced 19 to 24 inches apart on the flat or in double rows 14 to 16 inches apart on beds. The young plants can be thinned to a 9 to 10 inch spacing or even closer if they are to be harvested at a young stage of growth. A 1:1:1 or a 1:2:1 ratio in an amount that will supply 50 to 100 pounds of nitrogen per acre may be needed in cool, wet weather to give rapid growth.

Varieties.—Black or brown mustard is less desirable as a potherb. Its use is primarily in seed production for the manufacture of table mustard.

Giant Southern Curled, and Ostrich Plume or Fordhook Fancy are more popular than the rank-growing broad-leaf types. The Southern Curled has less finely cut and frilled foliage than the Fordhook Fancy. Tendergreen or spinach mustard (B. perviridis) grows very rapidly. It is well-adapted to the South and West. Tendergreen is slow to produce seedstalks.

The White London has rather deeply lobed leaves. The seed is a whitish-yellow in contrast to the dark brown color of the other varieties. This variety is useful in salads.

Harvesting.—The young plants are ready for cutting when four to five weeks old. The whole plant or the younger leaves may be taken. It is desirable that mustard be cut in the late spring as soon

as the plants are large enough. No opportunity is given for it to produce seed and become a troublesome pest. Mustard is package-iced for distant shipment.

FIG. 38.—The spreading habit of New Zealand spinach. Several edible tips cut from the plants appear in the foreground.

NEW ZEALAND SPINACH.

(Tetragonia expansa.)

Although introduced to England in 1771 the New Zealand spinach has been slow to achieve popularity. It is an excellent potherb, very easy of culture and produces its crop throughout the summer when many other greens do not thrive. It is not a spinach but there is some degree of resemblance between the thick, dark-green leaves of the two kinds. Plenty of nitrogen will increase the yield.

Propagation and Culture.—Seedlings may be started under glass and then transplanted to the field after danger of frost is over, or the seed which is really a fruit containing 6 or more seeds may be planted directly in the field, using 8 to 10 pounds of seed to the acre. Rows should be 4 feet apart or even 5 feet if a long cutting season is anticipated. The plants are spaced a foot in the row. Some hand pulling of weeds among the plants may be required. While the plants are still small, chicken or other fine manure can be side-dressed along the rows. Later if the plants begin to show a yellow color 20 to 30 pounds of nitrogen per acre should be ap-

plied as a side-dressing. Rain or irrigation will be needed to carry the nitrogen to the roots and to maintain a vigorous growth.

Harvesting.—Some 3 to 6 inches of the tender tips of the branches are cut with a knife. Buds in the axils of the leaves develop new growth so in time the plants present a much branched network of stems. Harvests can be taken every two to four weeks. As much as 200 crates or 6 tons per acre at each cutting have been obtained from well established beds. Heavy frosts kill the plants.

ORACH.

(Atriplex hortensis.)

Orach or mountain spinach is of somewhat stronger flavor than the true spinach. It was eaten boiled by the ancient Greeks. Its use in European gardens dates back many years but it is not common in America. Orach is recommended for the Great Plains region where the culture of spinach is not successful.

Propagation and Culture.—Orach should be seeded in a well-fertilized soil very early in the spring. Successive plantings at intervals of ten to fourteen days until summer will provide a continuous supply of young succulent growth. The fall crop is started in August or later when climatic conditions permit. Rows are spaced 18 to 24 inches.

Varieties.—The pale green or white and the red orach are most common. There are also darker green and copper colored varieties. Triumph is a popular variety.

Harvesting.—In five to seven weeks, the plants will be 4 to 6 inches high and suitable for harvest. The whole crop can be cut at this time or the plants thinned to a 3 foot interval. The leaves stripped from the branches of the mature plants are as tender as those on the young plants. These mature plants will produce seed for future planting.

SPINACH.

(Spinacia oleracea.)

It is believed that spinach was cultivated by the Persians over two thousand years ago, but apparently this crop was not known to the Greeks and Romans. The edible part consists of the compact rosette of leaves previous to the elongation of the central bud in flower-stalk formation. The extreme males produce seedstalks sooner than do the females, vegetative males, and the hermaphroditic plants, which have both male and female blossoms.

Fertilization.—The heavier loams and silts will produce probably the greatest yield, but for early spring growth and for overwintering a lighter well-drained soil is better. In the production of spinach for canning, muck soils have the advantage of reducing the possibility of grit in the canned product.

The soil should be thoroughly prepared, rich in organic matter and well drained. Spinach is shallow rooted so the fertilizer must be placed where it will be available to the roots early in the growth of the plant.

Spinach does best at a soil reaction of pH 6.0 to 6.8 but there is danger on some soils of reducing the acidity so much that a chlorosis or yellowing of the spinach foliage results. This chlorosis can sometimes be corrected if not too severe by spraying the plants with 10 pounds of manganous sulphate to an acre. The salt should be dissolved in plenty of water.

The lime may be harrowed into the surface soil which thus is made more suitable for the spinach. Later when the plot is plowed for the next crop and the lime mixed throughout, the soil reaction will be modified but slightly.

Liberal quantities of fertilizer are used to obtain rapid growth and high quality. On light open soils about 100 pounds each of nitrogen, phosphoric acid and potash per acre should be supplied. A half ton of 10:10:10 would do this. When spinach is planted on loam soils, the quantity of both nitrogen and potash can be less than on sandy soils, while on muck, the nitrogen only should be reduced. Side dressings of nitrogen will often be profitable on mineral soils.

In the West and Southwest spinach responds to phosphoric acid on some soils. Usually the crop is grown during the winter months when nitrogen is the most deficient nutrient. About 50 to 60 pounds of nitrogen per acre should be applied in bands near the seeded row at the time of planting.

Propagation and Culture.—Spinach is a short season crop requiring six to ten weeks to reach marketable size depending on climatic conditions. It will go into bloom when the days are long, although temperature influences also the flowerstalk development. Therefore its culture is limited in most sections of the country to spring, fall and winter. Plants which are 3 to 4 inches in diameter can withstand rather severe freezing, especially if protected by proper drainage against "heaving."

Fall, winter and early spring harvests result in seedings made from late summer to early winter. In the North, spinach should be planted as soon as the ground can be prepared. By use of the long-standing varieties a succession of plantings can be made in some

localities so that a crop is available for harvest almost continuously throughout the summer.

Seed treatment with Arasan, Semesan, zinc oxide, or copper oxide will aid in getting a good stand of plants. The rows are spaced 7 to 24 inches apart on the flat or two rows 12 to 14 inches apart on beds when furrow irrigation is to be given. When the entire plant is to be cut off for market the best development will take place if the plants are 3 to 6 inches apart in the row. Thinning may be justified. The processing crop which must be produced at low cost is not thinned. The plants should be usually 1 to 2 inches apart. A scatter plow of the 2 or 4 inch size on the planter will give a good distribution of plants. The rate of seeding depends on the row spacing, the viability of the seed, and the future use of the crop, so the rate varies from 10 to 20 pounds to the acre. Spinach plants are pulled sometimes when partly developed, and bunched for market. Then as much as 30 pounds of seed to the acre may be justified. The roots spread laterally some 12 inches and fill the surface foot rather completely. Shallow cultivation is practiced to prevent weed competition. A plentiful water supply is desirable to aid in rapid, continuous growth. Chloro IPC has possibilities for chemical weed control.

Varieties.–Most of the varieties in common use are of the smooth-seeded type. These may be separated into savoy-leaved and smooth-leaved groups. There are many spinach varieties but only a few are of importance in the United States.

The quick-growing savoy-leaved varieties which soon produce seed-stalks, listed according to their season of maturity and rapidity of bolting, are: Virginia Savoy, Old Dominion, and Dark green Bloomsdale Savoy. The first two are resistant to the mosaic blight and adapted especially for fall and overwintered crops.

The savoyed varieties that are slower growing and shoot to seed less rapidly develop approximately in the following order: Juliana, Long Standing Bloomsdale and America.

The smooth-leaved varieties are very desirable for processing since they are easily cleaned. Viroflay produces large plants but they are not especially long-standing. Nobel produces usually the largest plants of any spinach variety, but is not as long-standing as King of Denmark or Viking.

The prickly-seeded varieties such as Hollandia are not as widely planted as heretofore. They are smooth leaved and with Viroflay are the principal varieties used for processing.

Varieties with hybrid vigor are becoming available that are reported to give tremendous yields.

Harvesting.–When 6 leaves or more have been formed the plants may be severed from the tap root just below the lower leaves. A

knife, a hoe or a cutting edge mounted on a double-wheel hoe may be used. The plants should be cut before stem elongation takes place. When spinach is harvested for processing the plants are cut off about an inch above the ground either by hand or by machine. Equipment has been developed for cutting and loading the crop. One type cuts the whole plant for market spinach while others mow off the tops for freezing or canning. When the latter is done on spinach growing during the short days of winter and spring as many as four or more cuttings can be made before the seedstalks develop.

FIG. 39.—A plant of Old Dominion spinach. (Courtesy of H. H. Zimmerly.)

Yellow and diseased leaves should be trimmed off. For local market the spinach may be washed to freshen it. Bruises and broken stems from tank washing increase decay in shipment, but spray washing does not have this disadvantage. About as much ice as spinach is placed in each container for shipment to distant markets.

Yields of market spinach will be from 200 to 600 bushels (18 pounds) per acre in different parts of the country and at various seasons. The processing crop yields 2 to over 10 tons to the acre.

Insects and Diseases.—No satisfactory control for the *Leafminer* has been developed. See Swiss chard for further discussion. The control of *Aphids* is difficult even with dust because of the low growing habit and crumpled foliage. They can be especially serious in spinach grown for processing. A 1 per cent TEPP dust can be

applied even a few days before harvest if necessary. A 3 per cent nicotine or a 1 per cent rotenone dust usually give good control.

It is believed that *Mosiac or Blight* is spread through the field by insects, such as aphids. The use of resistant varieties offers the best method of reducing losses.

Downy Mildew or Leaf Mold is present wherever spinach is grown and is apt to be troublesome in wet seasons. Its control involves selection of a well-drained site. Varieties with resistance should be available soon. Spraying with zineb has been recommended using 1½ pounds in 100 gallons of water. It takes 300 to 400 gallons to treat an acre of spinach plants.

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Chapter 19

THE COLE CROPS

In this group are found a number of closely related members of the genus Brassica. The coles have thick bluish-green leaves, are hardy and thrive especially well in the cooler parts of the growing season. Their methods of culture are quite similar. Rutabaga, another cole, is discussed under root crops. (Chapter 22.) The cole crops, except for broccoli and cauliflower which are annuals, normally do not bloom until their second season of growth after they have been exposed to cool winter temperatures.

BROCCOLI.

(B. oleracea var. italica.)

The Italian green sprouting broccoli was thought by Vilmorin to be the first form of the early cabbage that was grown for its shoots. Introduced into the United States in the early 1920's, sprouting broccoli has gained rapidly in popularity. It is a cool-season crop making poor heads in hot weather.

Fertilization.—The soil should be well supplied with organic matter and not of too light a character. Readily available fertilizer applied liberally helps along the spring crop, and one or more side dressings of nitrate will sometimes be needed if growth appears slow. Usually 100 to 150 pounds of nitrogen to the acre with about the same of phosphoric acid and potash will be enough on soils which are not well supplied with these nutrients. Too fast a rate of growth from warm weather, wide spacing and heavy fertilization has been found in the West to cause a hollow condition of the central stem. In soils low in boron a stem and head condition similar to that caused in cauliflower may be encountered.

Propagation and Culture.—Plants may be started in hotbeds, coldframes or open plant beds depending on climatic conditions. Six to eight weeks' growth before transplanting to the field is enough under glass or cloth while four to six weeks in open beds will do. The rows in the field should be 36 to 42 inches apart with about 18 inches between plants, or even less for the early strains.

Where the growing season is long enough, the crop may be planted directly in the field, and thinned later to the proper stand. About 1½ pounds of seed per acre are used. In the West with two

rows on a bed, the plants stand 12 inches in the row but alternate in the two rows so they are about 18 inches on the diagonal. The closer the plants are spaced the fewer side shoots will be produced. The heads and shoots will still form when average temperatures fall to about 45° F. but the yield will be low if plant growth was not well developed before the cold weather arrived.

There is quite a range of maturities available among the broccoli strains. The very early and early strains are best adapted to the East or wherever the season is short. Early Green Sprouting, Waltham 29, Texas 107, De Cicco, and Green Mountain are in this

FIG. 40.—A compact central head of broccoli ready for harvesting. (Courtesy of Ferry-Morse Seed Company.)

group. Among the slightly later strains are Midway, Medium, Grand Central, and Green Cluster. The late strain grown during the winter months in the West produces few side shoots compared to the others. Broccoli rabe is a term used loosely in some markets to designate turnip, mustard or rape greens either vegetative or with partially developed seedstalks.

Harvesting.—As they develop the plants resemble cauliflower except that the leaves are more ragged and the central growth elongates. A cluster of dark-green flower buds some 3 to 6 inches in diameter develops. At first it is quite compact but gradually separates. Before the individual buds crack and show the petals

within, the head with some 8 to 10 inches of stem and attached leaves is cut. In the axils of the leaves remaining on the stalks lateral shoots or sprouts will be developing so that the harvest may continue several weeks. These snoots soon produce flower-bud-clusters ranging from 1 to 4 inches in diameter and are cut as was the central one. A second series will develop from these sideshoots. Most of the leaves are trimmed off the shoots cut for market before they are tied in 1 or 2 pound bunches. Immediate cooling and package icing are desirable if quality is to be maintained. In fact the broccoli should be kept iced until the consumer buys it, otherwise the buds and leaves soon turn an unattractive color.

The stems are cut to a 5 to 6 inch length for quick-freezing. The yield of broccoli should be 2 to 6 tons per acre depending on the variety, time of planting, and length of harvesting period.

Insects and Diseases.—Aphids tend to gather in the clusters of buds, as do the cabbage worms. A diligent program of control must be followed. See discussion under Cabbage.

BRUSSELS SPROUTS.

(B. oleracea var. gemmifera.)

This crop gets its name from the city of Brussels, Belgium, where it has been grown for several hundred years. Long Island, New York, and San Mateo and Santa Cruz counties in California, are the principal centers of production in the United States.

The plant is characterized by an unbranched stem bearing rather rounded leaves. In the axils of these leaves the sprouts or small buds develop. They are most delicately flavored. In warm weather the little leaves of these buds may fail to form hard compact cabbage-like heads, but rather be loose and open.

A cool moist climate and a good fertile soil are best. Organic matter should be supplied as manure or a green manure. Plenty of moisture is needed for proper development of the plant. Brussels sprouts should receive the same type of fertilization as late cauliflower.

Plants are started in the seed bed and transplanted to the field from May to late July depending on when the temperatures of the fall months in the locality will be favorable for the formation of hard buds. Rows are usually 36 inches apart with the plants set at 28 to 36 inch intervals.

Varieties.—The Long Island Improved is usually recommended. It is rather dwarf in habit with a compact distribution of the axillary buds. Half Dwarf and Fancymost 50-A do well in the West.

Harvesting.—In one hundred to one hundred and fifty days the basal buds will be 1 inch in diameter and ready for harvest. The

lower leaves turn yellow as the sprouts develop and should be pulled from the plant. This makes it easier to snap off the buds. Successive harvests are made from the base upwards as the buds develop. All the lower sprouts should be removed even though they fail to make solid little heads. The average acre yield of good sprouts is 3 to 4 tons. The sprouts after cleaning and trimming are sold in quart baskets or in cellophane bags. Drums holding 25 pounds plus ice are used for shipment. Sprouts must be kept at 32 to 34° F. during the marketing period.

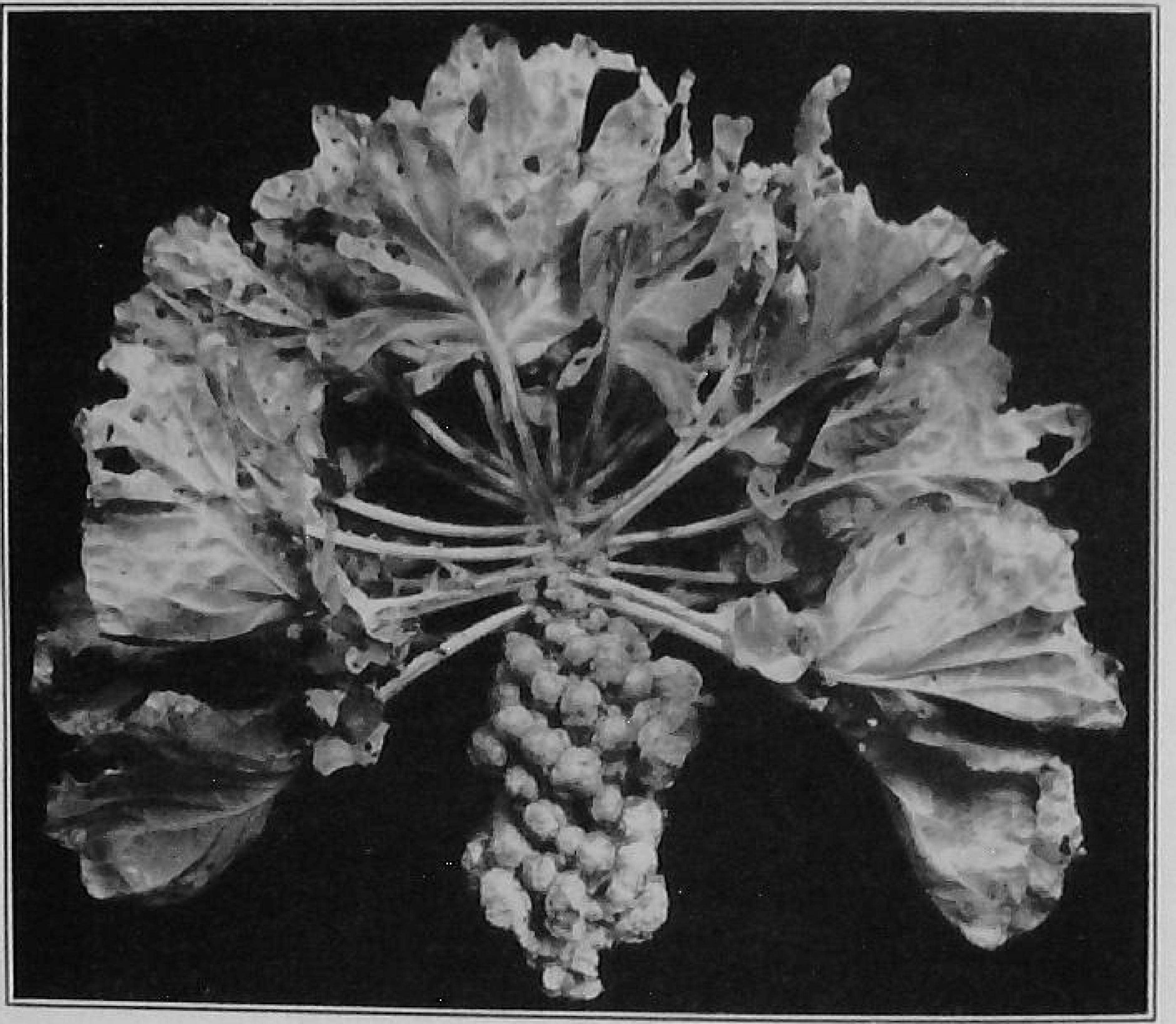

Fig. 41.—Brussels sprouts mature first at the base of the plant.

Light freezing does not injure Brussels sprouts, but is believed by some to improve the quality. As severe weather approaches, the plants may be cut or pulled and stacked in some sheltered place. A light covering of straw or other material will be sufficient to protect them. The buds are stripped as needed.

Insects and Diseases.—Although subject to many of the cabbage pests, the *Aphids* perhaps are the worst. Diligent care is required to prevent them from getting the upper hand.

CABBAGE.

(B. oleracea var. capitata.)

The culture of cabbage is one of antiquity extending back some four thousand to eight thousand years. The plant is a biennial,

producing the first year a rather compact leafy growth or head, surrounding the terminal bud. The second year the stalk emerges from the head and bears the blossoms.

A cool moist climate is conducive to the best growth of cabbage. Cabbage is planted to mature in early summer or fall in the North, and in late fall, winter or early spring in the South. In some sections of the Pacific Coast cabbage can be matured in all months of the year.

Fertilization.—Cabbage draws heavily on the mineral supplies of the soil. The light sandy loams are preferred for overwintering and for early cabbage in general. Muck and heavier loams are productive of larger yields of late cabbage.

Manure is less profitable apparently on early cabbage than on some other crops, but if it is not used then green-manure crops should form part of the rotation. When sod precedes early spring-planted cabbage, it is well to plow this under in the fall so its decomposition may commence. In preparation for late cabbage the land is plowed in the spring and harrowed sufficiently often to control weeds.

When the early crop is planted on light soils with little manure, the fertilizer should supply 100 to 125 pounds of each of the three principal nutrients. In some cases, a 1:2:2 ratio with more phosphoric acid and potash than nitrogen may be justified since it usually pays to side dress the crop with about 30 pounds of nitrogen as the heads begin to form. On heavier soils, relatively more phosphoric acid seems desirable as in a 1:2:1 ratio applied at a rate that will furnish the early cabbage with at least 75 pounds of nitrogen. Late cabbage, as usually produced, seldom justifies the use of more than 120 pounds of phosphoric acid applied as superphosphate. In case it is not grown in a well-manured rotation, a complete fertilizer of a 1:2:1 or 1:3:1 ratio may be used at a rate to provide 30 to 40 pounds of nitrogen; for example, 300 to 400 pounds of a 10:20:10 analysis.

In the Southwest and West, cabbage will usually respond to fertilization with 50 pounds of nitrogen per acre, part of which can be applied as a side-dressing. On soils known to be low in available phosphoric acid, 50 to 100 pounds of this nutrient should be applied per acre ahead of planting.

Propagation and Culture.—Glass-grown plants are started eight to ten weeks ahead of the probable time of field setting. They may be seeded very thinly in rows 3 to 4 inches apart in flats or beds and not transplanted or, for an earlier harvest, seeded closer and pricked out to a 1½ by 1½ or a 2 by 2-inch spacing. Greater room for development increases earliness if a good ball of roots and soil goes to the field with the plant.

Field or outdoor bed-sown plants will make sufficient growth in five to six weeks. Use an ounce of seed for 150 to 200 feet of row. In the South the seeding of plants for overwintering is delayed enough so that they will not be too large. The size reached before the plants are exposed to the low temperatures of winter together with an inheritable tendency seem to be the factors concerned in the "bolting" to seed instead of marketable head formation in these plants. In the West also the planting for spring harvest must be gauged carefully to reduce bolting.

Fig. 42.—The varieties used for late cabbage produce large-sized plants and heavy yields. (Boyle.)

Early cabbage is hardened and set before danger of severe frost is past. A long period of relatively cool weather after these early plants are well started may result in seed-stalk production the first year. The quick-growing varieties are grown at other times than spring in sections which have a climate suitable for the production of such market cabbage. Transplants can be used, or direct field seeding with subsequent thinning is possible where moisture is under control. In California 2 pounds of seed per acre are used for two rows on beds at 40 or 42 inch centers. Half as much is needed for single rows at a 30 to 40 inch spacing.

The term late cabbage is used commonly to refer to the slow growing varieties planted in the northern states for kraut manufacture or storage.

Late cabbage plants should not be grown in too rich a soil. They may be watered in periods of dryness but this should not be car-

ried to excess or plants of too succulent growth will result. Competition in the row for minerals and water on average land and under the weather conditions of June will result usually in enough of a check to harden the plants slightly. Thus they stand up after transplanting to the field better than if they had been given optimum growth conditions. When late cabbage is set with a transplanting machine it is most desirable that water be placed about the roots in the operation. In the late cabbage regions the plants are moved to the field the latter part of June.

The spacing in the rows depends largely upon the variety. Small types may be set as close as 12 to 15 inches but the larger growing sorts need 18 or more. The rows should be 24 to 36 inches apart. The size of head, to meet market demand, can be influenced bv close spacing. When transplants are set along one side of an irrigation furrow water can be easily supplied to get the plants off to a good start. Later soil is thrown against the plants filling in the old furrow as a new one is opened midway between the rows.

Cabbage which has been direct seeded in the field is thinned later to the spacing suggested for transplants. The quick-growing varieties planted two rows on a bed should be thinned so the plants alternate in the two rows, with 12 to 15 inches between adjacent plants in the same row.

Water is important in cabbage culture. A good content of soil organic matter is the first consideration. Irrigation for early cabbage is often profitable. The late crop suffers a decided reduction in yield if summer droughts are severe.

Cabbage roots soon fill the soil fairly well to the surface, and any deep cultivation will result in considerable root pruning. This may not be wholly a disadvantage in the home garden when it is desired to keep nearly mature cabbage heads from bursting. A sudden absorption of water after a period of dryness is thought to be a factor. Occasional twisting of the plants or breaking some roots by deep close cultivation may retard bursting. When cultivating to control weeds fewer leaves will be broken off if the operation is delayed until the plants have lost their morning turgidity.

Varieties.—Small plants with early pointed heads of high quality weighing 1 to 2 pounds, are produced by the Jersey Wakefield and the Charleston Wakefield. The Charleston is larger, a little less pointed and a little later. About as early a harvest as the Jersey is claimed for Golden Acre. The heads are slightly flattened globes, weighing about 3 pounds, of good quality, and surrounded by few outer leaves. Some Copenhagen Market strains are a week or more later and produce 4- to 5-pound heads. Early Round Dutch is a slow-bolting variety maturing about with Copenhagen. Bonanza,

popular in the South, is still later and somewhat slow to bolt. They can be used for winter and early spring harvest.

Mid-season harvests may be obtained from later plantings of early varieties, or by the use of second early sorts. Winningstadt has a pointed head with the leaves twirled about the peak. Glory of Enkhuisen is a large round type. All Head Early, Succession and All Seasons are flat types varying in depth. Slow Bolting Flat Dutch, a second early variety of excellent quality, is adapted to fall seeding for spring harvest where winter temperatures average between 45° and 50° F.

For late storage cabbage the Hollander or the Danish Ball Head with short or medium length stem is most favored. Late Flat Dutch is grown to some extent.

Red cabbage is useful for pickling. The Savoy with attractive dark-green crinkled leaves of slightly different flavor has not gained the popularity here that it has abroad.

Harvesting and Storing.—Early cabbage is cut in many cases before the head is firm in order to take advantage of a high market. Usually when the head has reached the maximum solidity for the particular variety it may be bent over and severed from the stem and basal leaves with a sharp knife or hatchet. Several cuttings are made in early cabbage fields but late cabbage is harvested at one time.

The yield of the early crop is from 6 to 8 tons an acre, while late cabbage may be expected to produce 10 to 20 tons.

If the heads are to be put in storage they should be handled carefully to reduce bruising. They may be piled in layers 3 to 4 feet deep in narrow bins about 3 feet wide and 10 to 12 feet long, boards being used to separate the different layers. In some storages the heads are placed in a single layer on shelves. With either method plenty of space is given for free air circulation around the piles of heads. The temperature should be held down to as close to 32° F. as possible.

Insects and Diseases.—Cabbage suffers from the attacks of a number of insects and diseases which are troublesome on many of the other members of the Mustard family. Some of the diseases resemble the condition resulting in cases of malnutrition. Excessive fertilizer applications and a low soil organic matter content may cause a sickly growth of cabbage which is not due to any causal organism.

The *Cabbage Maggot* is the larva of a small gray fly, which lays its eggs on the stem or just under the soil nearby. It seems to attack radish more readily than other members of the mustard family. These eggs look like pieces of white thread about 1/25 inch in length. Upon hatching, the maggots burrow into the tender roots

and stems. Growth of the plant is checked, it becomes bluish-green, wilts and may die. This insect is primarily a problem in the spring months.

A 5 per cent chlordane dust at 40 pounds to the acre may be raked into the top 2 inches of the plantbed before seeding or else, after the young plants are up, 40 to 50 pounds of this dust can be placed on the surface along the rows. Bichloride of mercury at 1 ounce in 10 gallons of water or calomel at 1 ounce in 8 gallons of water could be poured along the rows in the plantbed at the rate of a gallon to 35 or 40 feet of row.

The roots and stems of transplants are sometimes dusted with a 5 per cent chlordane dust. In place of this method 2 liquid ounces of 40 per cent chlordane emulsion might be put in 50 gallons of transplanting water. From ½ to ¾ of a cup of this liquid must be dropped exactly where the plant is to be set. The bichloride of mercury and calomel at the rates mentioned above are used in a similar manner. They may also be poured around the stems of plants a couple of days after transplanting and again ten to fourteen days later. Plants might be treated in the same way with ¾ of a cup of a chlordane suspension. This is made by putting 1 pound of 50 per cent wettable powder of chlordane in 50 gallons of water. The suspension must be kept constantly stirred. A chlordane emulsion is used in the same way, as are aldrin, dieldrin and heptachlor.

The *Cabbage Worm* hatches from the yellow eggs laid on the leaf by the white butterfly with black spots near its wing tips. Several other worms attack cabbage. In the early stages of growth a 20 per cent calcium arsenate dust or 3 to 5 per cent DDT or DDD dust have been recommended for control. Some of the organic phosphate insecticides are very effective but must be used with great care. As cabbage, broccoli and other crucifers approach maturity, insecticides non-poisonous to humans must be used. The plants should be covered well with a 1 per cent rotenone dust or a pyrethrum dust or equivalent sprays. The *Cabbage Looper* is controlled by pyrethrum and the larvae of the *Diamond-Back Moth* by rotenone. The DDT used for worms will check the *Flea Beetles.*

The *Harlequin Cabbage Bug* which is a sucking insect causes greater losses in the South than in the North. It is shiny black with bright orange marks. Hand picking, sanitation and the use of a trap crop such as kale or horseradish are methods of holding it in check. A 15 per cent Sabadilla dust is useful.

Aphids are always a problem on these crops. Repeated applications of 1 per cent parathion, 1 per cent TEPP, 5 per cent malathion, or 3 to 4 per cent free nicotine dusts at 30 to 50 pounds per acre are necessary to prevent them from getting a foothold. Sprays of comparable strength can be used.

Blackleg appears as a dark sunken girdle about the stem near the ground level. The plant may wilt, lean or fall over and die. The dead areas are covered with raised black specks which are the spore-forming bodies of the fungus. Diseased plants may be removed and burned. A rotation of at least four years should be practised as the fungus can exist in the soil. The choice of a disease-free seedbed is important. Since blackleg is also seed-borne, hot-water treatment at 122° F. for twenty-five minutes has been found effective but germination may be reduced.

Club-root is caused by a slime mold, which can exist in the soil for some years, entering the roots and causing swellings, which are thickest near the primary root. This distinguishes it from *Root-knot* caused by a microscopic eelworm or nematode, which produces swellings that are smaller and more evenly distributed on the lateral roots. Losses from club-root can be reduced by rotation, clean plants, destruction of diseased plants and the application of hydrated or quicklime, six weeks before planting, in an amount great enough to shift the soil reaction to pH 7.2. The bichloride of mercury or the calomel used in the transplanting water for maggot control will check club-root as well. Varieties with resistance to this disease are being developed. Root-knot control is discussed in Chapter 13.

The fungus causing *Yellows* persists in the soil and is widespread throughout the United States, being most destructive in regions where the temperature is high during the growing period of cabbage, as in the corn belt. Plants become stunted, turn yellow with a brownish tinge to the veins. Disease-resistant strains or varieties such as Wisconsin Hollander, Wisconsin All Seasons, All Head Select, Marion Market, and Globe have been developed for use on yellows-infested soil.

The bacterium of *Black Rot* borne on the outside of the seed coat, and capable of remaining in the soil for four to five years, is responsible for this disease. Heads may be dwarfed or fail to develop. The leaves look yellowish, with black veins. If the stem is cut a black ring can be noted near the vascular bundles. The control measures suggested for blackleg are efficacious also for black rot.

Downy mildew may be serious in cool damp weather. Treatment for this disease and *Leaf Spot* involves spraying every few days with Spergon in the plantbed and nabam in the field.

CAULIFLOWER.

(B. oleracea var. botrytis.)

Cauliflower is quite specific in its climatic requirements and therefore a more difficult crop to grow than cabbage. Cool tem-

peratures with plenty of moisture and considerable humidity are necessary as the plants develop. There are two general types in use; the quick-growing varieties used in most of the country and the slow-growing ones planted in the West for winter maturity.

Fertilization.—A sandy loam soil is advantageous for the early crop, while a deep, rich loam is preferred for late cauliflower. The soil reaction should be above pH 6. If manure is not added then the soil organic content should be increased by green manure crops. With less than 10 tons of manure on sandy soils, cauliflower should receive 100 to 150 pounds of nitrogen and about 150 pounds each of phosphoric acid and potash per acre. The nitrogen can be reduced on silt- and clay-loam soils to give a 1:2:2 ratio. Side dressings of nitrogen stimulate growth. If boron is deficient, the curds show a browning and the inside of the stems may be cracked and hollow. This difficulty can be corrected by the addition of 10 pounds of borax to the quantity of fertilizer used per acre although alkaline soils may require more than this quantity. Application of 100 pounds or more of magnesium oxide or 50 to 100 pounds of manganous sulphate to the acre have been found to be needed in localities where these nutrients are deficient.

Very acid soil renders molybdenum unavailable. This results in a whiptail condition of the foliage. The soil reaction should be brought to pH 6.0 to 6.5. In special cases ½ to 1 pound of sodium or ammonium molybdate can be applied per acre as a foliage spray.

Propagation and Culture.—Early and late crops are grown. The dates of seeding in each case are a little later than the corresponding crops of cabbage. The plants are grown and handled in a similar manner, but the young seedlings are not quite as hardy as cabbage. Care must be exercised to prevent an excessive check to the young plants from holding them too long in the flats or seedbeds. This may cause them to "button" before or after being set in the field. The inability of the plants to absorb enough nitrogen from the soil of the plant bed or from that in the field after they are set out will restrict their leaf growth. This makes the little curd stand out unprotected by foliage. A low content of nitrogen in the soil, a dry soil, a mutilated root system due to the transplanting or to insect injury will cause the plant to be low in nitrogen and so show buttoning.

Most of the crop for fall and winter harvest is grown in plant beds with 12 to 14 inches between rows. It takes 4 pounds of seed to plant an acre of plant bed which will provide plants to set about 20 acres. In New York these beds are started about June 1, while in California they are planted from mid-May to late in July depending on the variety and locality. Snowball cauliflower is seeded directly in the field in many parts of Arizona and California since

it tends to "button" there if transplanted. Usually 1 to 2 pounds of seed is used to the acre. Plants are spaced 18 to 20 inches in rows 24 to 36 inches apart, or even as much as 42 inches with furrow irrigation. Transplanting machines speed field setting. Cloudy days or late afternoon transplanting will aid plant survival. Cauliflower is a shallow-rooted crop so irrigation may be needed to maintain a steady vigorous growth. Moisture is very important in getting the young plants established in warm weather. Weed growth must be suppressed but cultivation must be very shallow.

Blanching.—Unless the young head is protected from the sun and rain it develops a brownish color instead of a clear white and

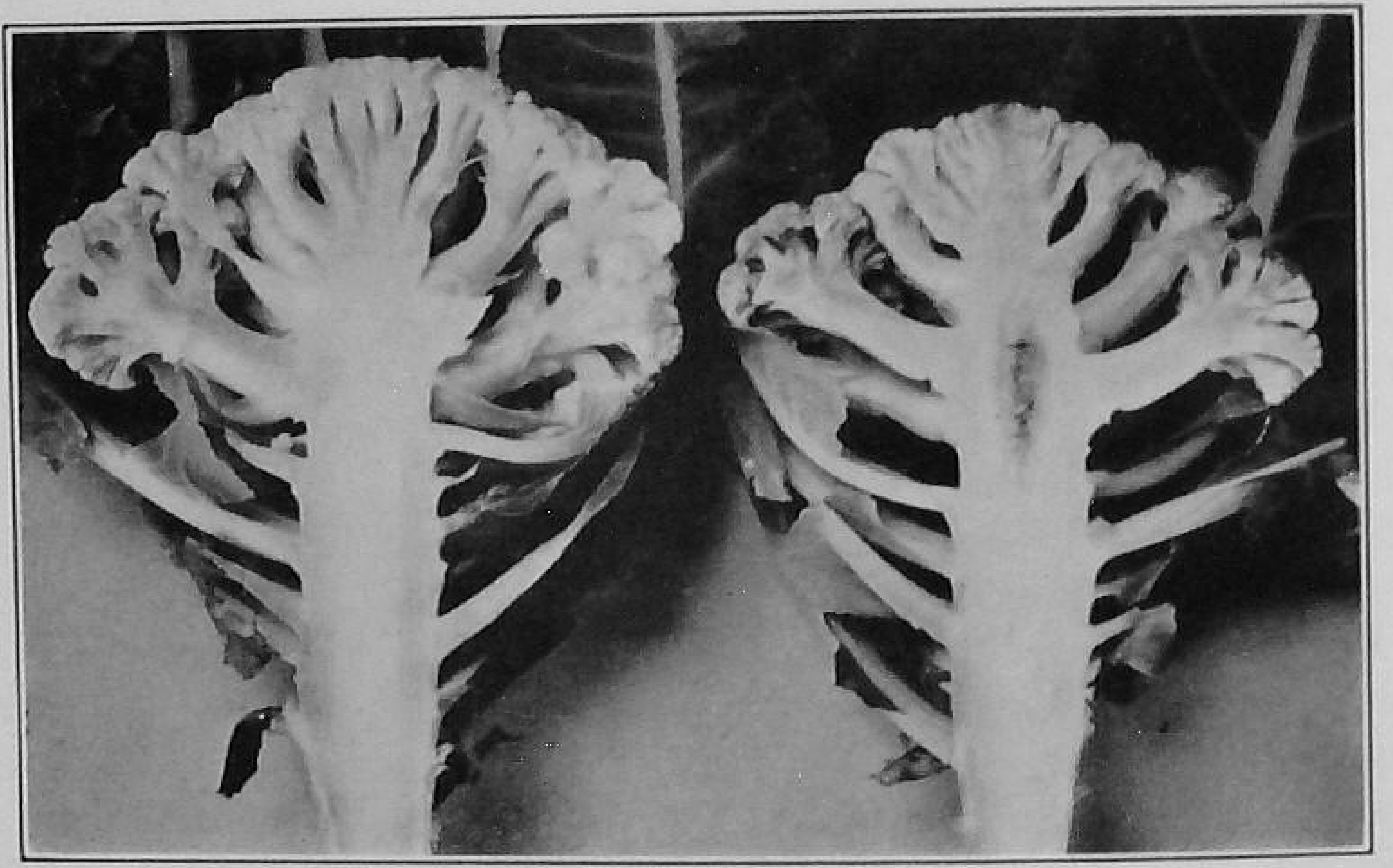

Fig. 43.—Lack of boron resulted in the discolored curd and internal breakdown in the head on the right. (Courtesy Cornell Univ. Agr. Exp. Sta.)

numerous leaves may appear between the segments of the curd. Soon after the cauliflower head is 2 inches or more in diameter the leaves must be drawn about it. With a very vigorous plant one may break the mid-ribs of some of the leaves, fold them over and, if necessary, hold them in place with a small pointed stick. Tying is preferable and if a different colored soft string is used each time the plants are tied, later harvesting is simplified. Those tied up on a certain day are likely to be right for cutting together. Rubber bands cut from an old inner tube have been used. Instead of using string some growers tie two long leaves themselves together holding the others down over the curd. By taking a pair with the row one time and at a right angle to the row for the next tieing or at intermediate positions the different maturities are apparent. The

curds of the late varieties used in the West are protected by incurving leaves so do not need tieing.

Varieties.—An ounce of cauliflower seed costs as much as one would pay for a pound of cabbage seed. The importance of a carefully selected strain of cauliflower cannot be overemphasized.

There are two types of cauliflower. The quick-growing Snowball was developed in Holland and Denmark. There are a number of strains of this variety which differ in the rapidity and uniformity with which the heads mature. The slow-growing, late or winter

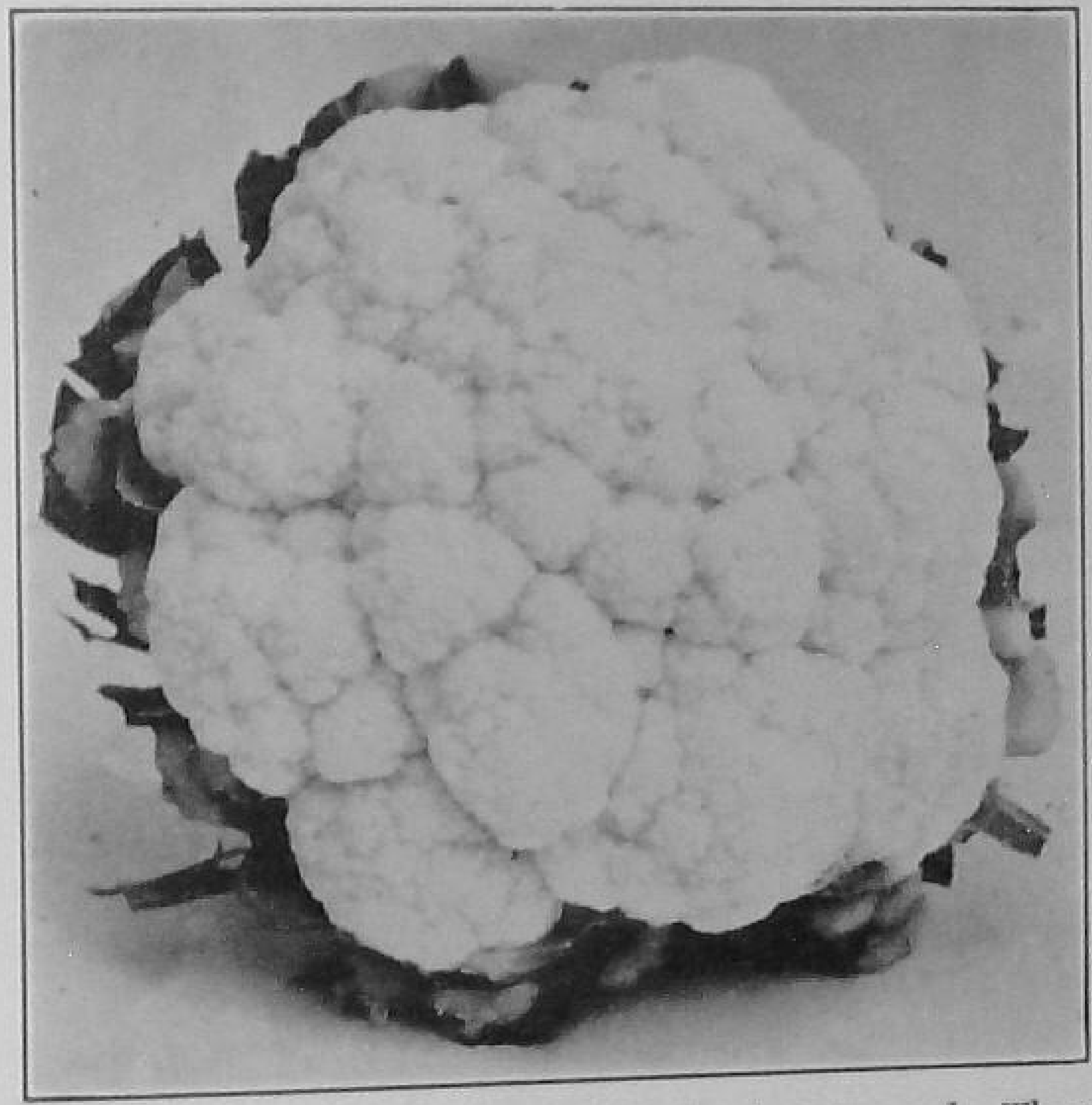

FIG. 44.—A well-formed curd of cauliflower closely trimmed. There is no evidence of ricing or of leaf growth in the head.

type stems from the Mediterranean region. It is used on the Pacific coast. The varieties are named for the particular month from November through April in which each will mature with highest quality.

Harvesting and Trimming.—In good growing weather the heads may be ready to harvest in two or three days after the curds are protected. In the fall several weeks may elapse. If left too long spots of rot will develop, spoiling the head for market.

The size of head depends somewhat on the plant, so the condition of the curd is the criterion by which to judge maturity. In hot weather the compressed flower parts will arise from the surface or make a "fuzzy" head; the peduncles of the flower parts will elongate, causing "riciness" or separation of the head; or a "leafy"

head may be formed through the appearance of leaf edges between the segments of the curd.

On some markets the heads are sold with the leaves untouched, allowing the merchant to trim them. The head is protected on the way to market, and the cuts appear fresher to the customer. For shipment the leaves are cut off about an inch from the surface of the curd, in order to give it protection in the crate.

An acre should yield 5000 to 6000 heads weighing 1 to 4 pounds apiece. These would pack 300 to 400 pony crates, each containing 9 to 12 heads in a single layer, or proportionally fewer of the larger crates used in New York where it is customary to pack two layers of heads, butt to butt.

Insects and Diseases.—Cauliflower is subject to many of the pests described for cabbage, particularly *Maggot, Clubroot, Black Rot* and *Blackleg.* Rotenone dust will control the green *Cabbage Worms. Whiptail* is a malnutrition disorder encountered on very acid soils.

COLLARDS.

(Brassica oleracea var. acephala.)

Although rather popular in the South this biennial vegetable is in less demand in the North than other better-flavored Brassicas. It has been described as a non-heading cabbage, resembling the tall kales in habit of growth, with smooth rather than crimped leaf-blades. Since it will stand more heat than cabbage it is substituted for that crop in warmer regions, and may be carried through the winter also in such localities.

Propagation and Culture.—Plants are grown and the crop cared for much in the same way as cabbage. A good fertile soil will produce a more desirable growth. Seed is sown in seedbeds very early in the spring or in mid-summer. It is possible also to seed in place and thin. The spacing given is 1½ to 2 feet in rows 3 to 4 feet apart. Georgia collard and Louisiana Sweet collard are the principal varieties.

Harvesting.—Whole young plants may be cut or the tender leaves at the top stripped off. The flavor of the foliage is believed to be improved by frost.

KALE OR BORECOLE.

(Brassica oleracea var. acephala.)

This biennial crop and the collards are probably more closely akin to the wild form of cabbage than any of our cultivated kinds. Kale has been grown by man for several thousand years and today

is one of the more important potherbs. Many of the varieties are quite ornamental with their attractively colored and closely frilled foliage. Kale continues to grow in warm weather and is able to withstand mild winters.

Fertilization.—A well-drained, well-prepared sandy loam is ideal, although kale will thrive on any good soil. Rather large quantities of fertilizer are given to insure high quality. A good content of organic matter is helpful also. The proper rate of fertilization is considered to be about 100 pounds per acre of nitrogen and potash with twice that quantity of phosphoric acid. Side dressings of nitrogen speed growth.

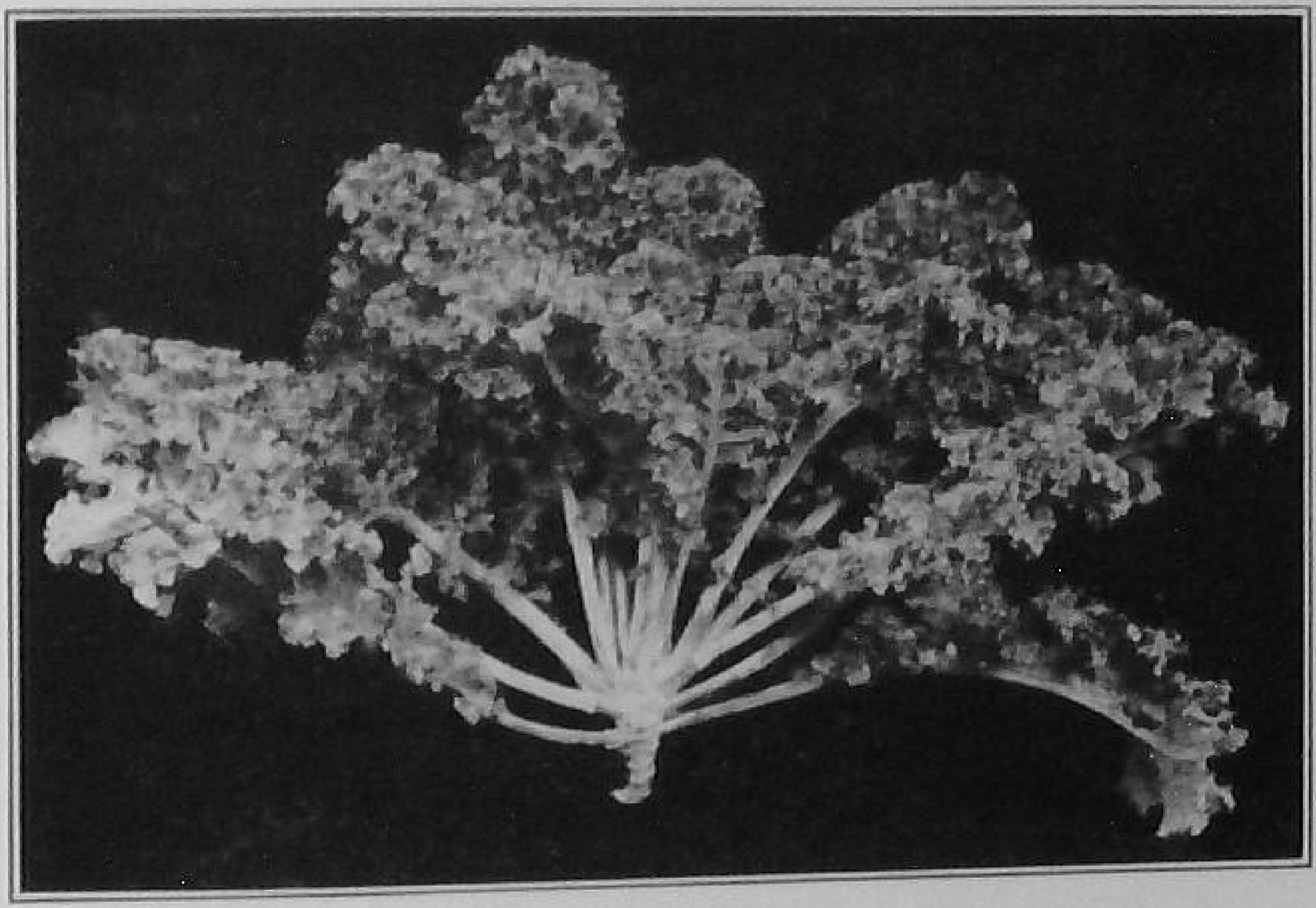

FIG. 45.—A Scotch kale plant.

Propagation and Culture.—Kale is usually seeded in place and the plants thinned to 6 to 12 inches. A space of 18 to 30 inches is allowed between rows.

In the North very early spring or mid-summer seeding is common, but in the South the crop is seeded from mid-summer to September for harvest in the fall, winter or early spring. Raised beds may be used for the overwintered crop. Weed growth must be prevented.

Varieties.—The dwarf varieties are more widely grown than the taller ones. The Siberian group which has slightly curled foliage is considered to be more hardy than the Scotch. Lighter green foliage excessively curled and of somewhat better quality characterize the latter.

Harvesting.—Freezing is thought to improve the quality and render more edible the older leaves with their stringy mid-ribs. For

marketing the whole plant is severed from its root near the ground, trimmed and packed. For home consumption the tenderer leaves may be cut off. Yields of 150 pounds from a 100-foot row or 350 bushels and more an acre are obtained.

Insects and Diseases.—Many of those affecting cabbage, especially *Aphids,* will be found on kale.

KOHLRABI.

(B. oleracea var. gongylodes)

This vegetable is one of the most peculiar crops we have. Its use as a food does not date back very far in history. The edible portion is the swollen stem, which develops entirely above ground. This is used in the manner of the turnip but is more delicate in flavor and texture than that vegetable.

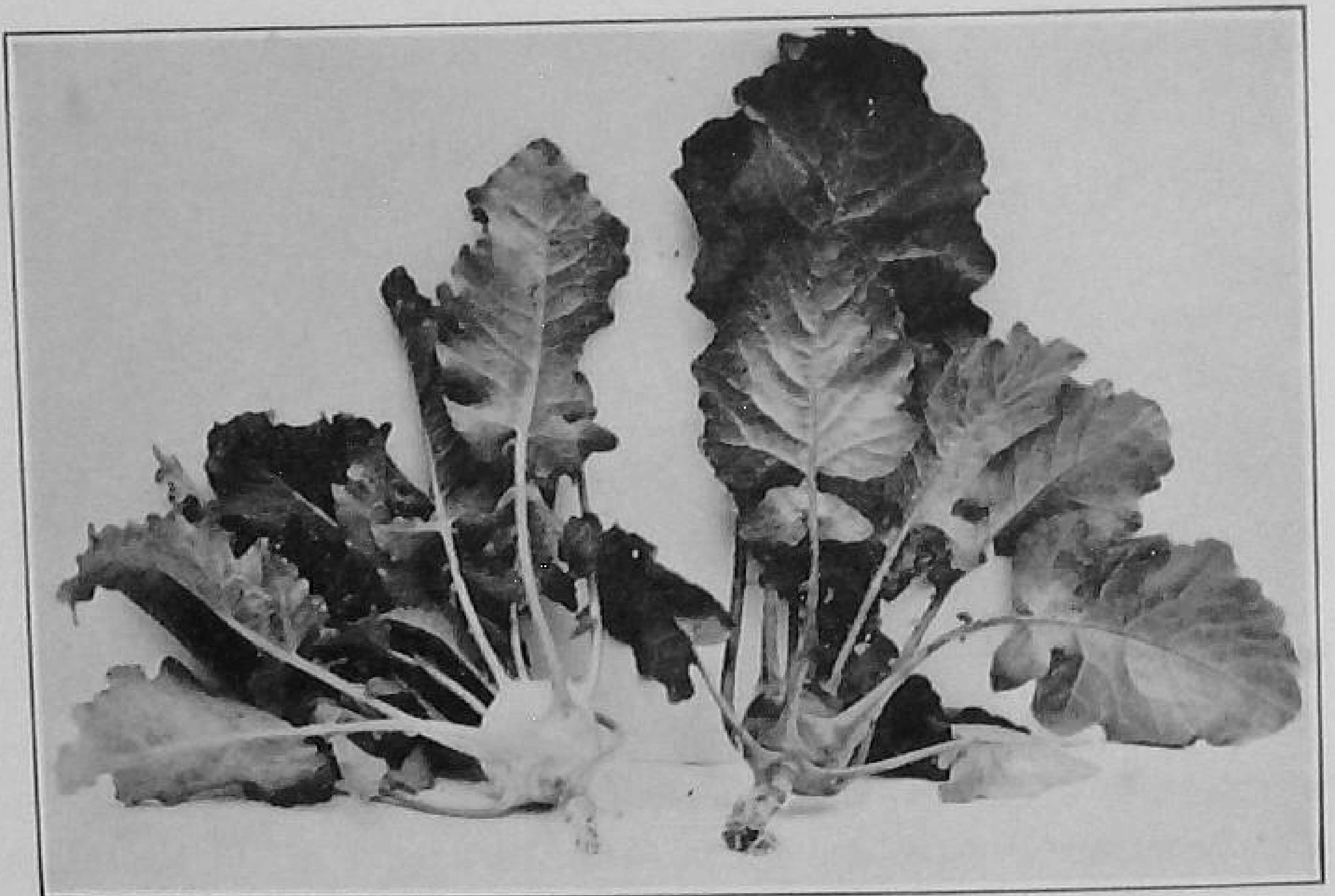

Fig. 46.—The White and Purple Vienna kohlrabi are among our oddest vegetables. They must be harvested while small to be tender.

Kohlrabi is a cool-season crop and does best if grown in the spring and fall. For an extra early harvest plants may be grown under glass like those of cabbage and transplanted to the garden at the same time. Plants should be set at 2 to 3 inch intervals in rows 18 to 24 inches apart or in two rows 12 to 14 inches apart on beds if furrow irrigation is used. When seed is planted where the crop is to mature, the seeder should be adjusted so that there will be a stand of about six plants to the foot. Thus thinning can be eliminated.

Rapid growth is desirable for the development of a tender product. The fertilizer suggestions made for cauliflower are applicable to kohlrabi. White Vienna is earlier and more popular than the Purple Vienna.

When the swollen stems reach a diameter of 2 to 2½ inches the plants are pulled and the stems pared off just below the swelling. Several are tied in a bunch. The stems soon become tough and woody if permitted to develop further. An acre should yield 16,000 bunches. In the fall the leaves can be trimmed off and the kohlrabi stored without difficulty in a root cellar.

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Chapter 20

THE SALAD VEGETABLES

THE use of uncooked vegetables as salads has been stimulated greatly by research on the vitamin and mineral content of leafy tissues. Although the salad may include chopped up carrots, asparagus tips, cooked potatoes, or almost any other vegetable, yet the background or decorative aspect is furnished often by some member of this group.

These vegetables are quick-growing and essentially cool-season crops. A good soil, with sufficient moisture and readily available minerals will insure rapid unchecked growth resulting in high quality. Tough, bitter wilted plants make a poor salad.

CELERY.

(Apium graveolens var. dulce.)

As a medicine the use of celery dates back many years, but it was not until about the sixteenth century that it was utilized as a food. The early use was in soup and broth. It now ranks close to lettuce in popularity.

Celery is not tolerant of very high temperatures so, except in especially favored localities, its culture is limited to the North for summer and fall crops, the South for winter and early spring crops and to California where it is grown in fall, winter and spring. There is enough diversity of producing areas together with the possibility of storage to take celery out of the list of luxuries and place it on the markets the year round. It is a biennial plant.

Fertilization.—The heavy clay loam soils are not as well suited to celery production as are the sandy and silt loams. Muck is the ideal medium for growth, since it has already that good water-holding capacity which must be built up in mineral soils by the use of heavy applications of animal manures or turning under of green-manure crops.

Thorough preparation should be given any kind of soil for success with celery. The soil reaction should be about pH 6. Manure is especially valuable for celery on mineral soils. Early celery should receive a heavier application of fertilizer than late celery. One or more side dressings with 30 to 50 pounds of nitrogen per acre are justified on all soils.

On loams a 1:2:2 ratio will usually be satisfactory. The rate of application would vary from 75 to 100 pounds of nitrogen according to the level of fertility. A 1:1:1 or a 1:2:2 ratio is suggested for sandy soils at a rate somewhat heavier than on the loams. In Florida on the sandy soils analyses of these ratios are used several times during the growth of the celery so the total application may reach 240 pounds of nitrogen per acre.

Peat and muck soils in the East and Northwest receive a 1:2:2 or a 1:2:3 ratio for celery. The rate per acre increases from 80 to 100 pounds of nitrogen as the spacing of the plants is decreased. In the Middle West the 1:3:6 or 1:3:9 ratios are common for celery on muck soil. They are used at a rate to provide 60 to 75 pounds of nitrogen to the acre. An 0:1:3 ratio with the nitrogen supplied as a sidedressing is recommended on good mucks with the application giving 180 to 200 pounds of phosphoric acid per acre. Celery on Florida muck is fertilized with about 240 pounds of phosphoric acid an acre in a 0:3:4 ratio. Nitrogen sidedressings are given as needed. In California celery on peat soil responds to 200 pounds of each of the three nutrients in a 1:1:1 ratio.

In most production areas in California on mineral soils, celery has responded to as much as 400 pounds of actual nitrogen to the acre. Such heavy fertilization as this should be given half at the time the plants are set and the remainder midway in growth. Additions of phosphoric acid and potash have not modified growth or quality.

"Cracked stem" due to boron deficiency requires the addition of 10 to 15 pounds of borax per acre with the fertilizer or later. More is needed on peat soils.

Certain varieties, notably Utah 10-B, are inefficient in absorbing magnesium and boron from the soil. Lack of magnesium gives a yellowing of the foliage that has been corrected by putting 2 to 4 pounds of magnesium sulphate in the quantity of fungicidal spray material used to the acre. The boron disorder in this case is a breakdown of the inside of the petiole, and has been called "brown checking." It may or may not be accompanied by "cracked stem." When the young plants have 10 or more leaves a thorough spraying with 8 pounds of borax or 4 pounds of boric acid to the acre is recommended.

The breakdown of the young leaves in the center of the plant is known as "blackheart." It appears to be due in part to the failure of these tissues to receive sufficient calcium when growth is rapid. Spraying the heart of the plant with a solution of 5 pounds of calcium nitrate in 100 gallons of water at seven to ten day intervals will correct this disorder. The treatments should begin when the imminence of blackheart is suspected or the first traces are observed.

Propagation and Culture.—Celery seed requires that the soil moisture be close to field capacity in order to get good germination. Even then it may take ten to twenty days for the seedlings to appear depending on the soil temperature. This makes direct field seeding difficult but it can be done and the plants thinned later.

Usually celery is started under glass eight to ten weeks ahead of field setting, or in an outdoor plant bed ten to twelve weeks before the plants are to be lifted. When it is to be planted outdoors the seed can be sprouted between layers of moist cloth either for

Fig. 47—Boron deficiency causes a cracking of the back and a checking of the inner surface of celery petioles. (Courtesy of California Agr. Exp. Sta.)

direct seeding or for plant growing. As soon as the sprouts appear the seed is dried by mixing with dust or meal and sown immediately. It should be barely covered or just pressed into the moist soil.

When started in flats a double layer of wet burlap should be laid over the soil. Watering through the burlap prevents washing out of the seed and aids in maintaining constant moisture at the surface whether the seeds have been broadcast and covered with a little soil or are uncovered in little furrows the length of the flat. The cloth must be removed as soon as the seedlings appear.

Even four or five weeks after seeding under glass the plants are quite small and the job of pricking them out into flats is slow and expensive.

Weeds are readily controlled in the celery plant bed by spraying the whole area with herbicidal oil at the rate of 50 to 70 gallons per acre.

When grown under glass the plants should be held at about 75° F. in the day and 60° F. at night. Outdoor plant beds should not be started until the weather is warm enough. If celery seedlings are exposed to temperatures averaging 50° F. or below for a week or more there may later be considerable bolting, especially of those individuals with the greatest inherent tendency to "shoot to seed".

When ¼ inch or so in diameter at the crown the plants are ready for field transplanting. If the tops are too large and water cannot be applied following transplanting, less wilting may occur if the outer leaves are trimmed somewhat. Celery should not be set out until danger of heavy frost is over. Freezing does not increase the possibility of premature seedstalks but the relatively low average temperature usually accompanying the freezing weather does have this effect.

The hardening of celery plants previous to field setting should be accomplished by withholding water.

A spacing of 6 to 8 inches in rows 1½ to 5 feet apart is given. When boards or paper are to be the means of blanching the rows need be less distant than if soil is to be banked about the plants. Special machines for transplanting celery have been developed. These are best adapted for planting celery on the flat. Where furrow irrigation is used the machine may open a furrow as the plants are set. Most of the furrow irrigated celery is set by hand either on one or both sides of the bed. The water can be run in the furrow first and the roots pressed into the soft soil, or the plants set first and water run down the furrow immediately afterward.

Setting the plants in a trench to get them into moist soil seldom produces benefits sufficient to pay for the extra work. Moreover, there is greater danger of rot if water stands in the ditch after a rain, or the heart may be covered as soil is thrown in from cultivation. It is more difficult to harvest plants set out in a trench.

In the coastal areas of California much of the celery is seeded directly in the field. Usually 1 to 1 1/3 pounds of seed are planted in two rows on a bed as is lettuce. The soil is kept moist constantly by furrow irrigation for two to three weeks. Oil sprays control the weeds during early growth. Subsequently the plants are thinned to 6 to 8 inches apart.

The root system of celery is relatively compact with fibrous roots near the surface. When the plants begin to develop well they can

quickly deplete the available moisture in the surface foot or so of soil. The large quantity of green matter produced per acre is a factor in this use of water. Therefore, careful attention must be paid to frequent replenishing of the water if steady growth leading to high quality celery is to be obtained.

Weed growth must be eliminated by shallow cultivation. Herbicidal oils, while useful on young plants in the plant bed, appear to be injurious to celery after it has been transplanted to the field.

FIG. 48.—A self-propelled celery transplanter. A plant is placed in each clip and is automatically released when it reaches its proper position in the row. (Courtesy Cornell Univ. Agr. Exp. Sta.)

Varieties.—Golden Plume or Wonderful is a popular yellow celery. Strains of it differ in height, resistance to Fusarium Yellows and resistance to premature bolting. Golden Self Blanching strains vary in height, stem characteristics and disease resistance. These two varieties are quick-maturing. They blanch readily to a golden yellow, while the green varieties, if blanched, become a whitish cream.

Cornell 19 and 619 combine the fleshy high-quality stems of the Utah type with the ready blanching of the Golden type. Public demand favors green celery so the yellow varieties are not as commonly grown as in the past.

Easy Blanching is a quick-growing green celery. Summer Pascal is a very high quality green celery with thick fleshy petioles, somewhat slower in maturing than the above.

Most of the green celery produced for shipment is of the Utah variety. There are several strains. The stems of Utah are thicker, smoother and more numerous than those of Giant Pascal, which is a late green variety used for winter storage. Utah 10-B, Utah 15, Utah 16 and Utah 52-70 have different seasonal adaptations which may dictate a choice of one or another. Emerson Pascal has considerable resistance to early and late blight.

FIG. 49.—The stalks of self-blanching varieties will turn yellow when well shaded by the foliage.

Blanching.—Most celery is now harvested without blanching. The yellow or self-blanching varieties do get some natural bleaching from the shading effect of the foliage as the crop matures. This occurs also in the hearts of the green varieties. The shading is more effective when plant growth is vigorous and the plants are not too far apart.

In some peat soil districts the soil is banked high on each side of the row of plants primarily to provide protection from freezing in the late fall months.

Harvesting and Storing.—The individual plants may be cut 1 to 2 inches below the crown with a sharp spade, knife or by a special cutting machine drawn by horse or tractor. When the celery is to be placed in storage the poorer outside leaves are removed in the field and the stalks packed into crates. For movement direct to market the plants are trimmed more closely and either packed in crates in the field or taken to a packing shed.

Some celery harvesting equipment cuts off the tops to a 16-inch length at the same time the roots are severed. Otherwise the tops are cut to crate length after packing in the field, or mechanically as the celery passes over the trimming tables in a packing shed. Elaborate machinery used in Florida provides facilities for packing and washing on a mobile platform as it moves slowly through the field. The crates are then ready for transport to the precooling plant.

The acre yields vary among districts according to the spacing of the rows and plants. In many states the average is around 400 to 600 crates while in others it is between 750 and 1000 crates. These so-called half crates hold about 60 pounds of trimmed celery.

Celery may be stored for a few months in trenches, pits or special cellars, with more or less soil attached to the roots. Cold storage is more satisfactory.

Insects and Diseases.—A number of the common garden insects may be found on celery. *Carrot-rust fly* sometimes attacks celery. The *Tarnished Plant Bug* attacks many vegetables. The injury to celery is manifest by a discoloring of the joint where the leaves are attached to the petiole. Thus the name "black-joint." Dusting with DDT will control the bugs but the celery must be thoroughly washed before use. DDT should not be used during the three weeks previous to harvesting.

Of the diseases, *Early Blight* is distinguished by elliptical, ashen gray-colored spots surrounded by a light-yellow band. Dusting is not as effective as spraying for early blight. To control this blight and the two which follow, the foliage should be coated with Bordeaux mixture several times in the seedbed and at intervals of ten to fourteen days, during growth in the field. *Late Blight* forms small, round, brown spots with black, raised dots. Hot-water treatment of seed, or use of three- or four-year-old seed, and protection with Bordeaux, the dithiocarbamates, or insoluble copper are recommended. *Bacterial Blight* resembles late blight but does not have the black pycnidia or pimples. Dusting seems to be even more effective than on late blight. *Yellows* causes stunting, yellowish foliage, and a yellowish-red discoloration in the vascular tissue at the base of the plant. The causal fungus lives in the soil. The green varieties show more resistance to the disease than do most of the yellow ones. Resistant strains of the Golden type have been developed. *Pink Rot*, caused by a *Sclerotinia*, is controlled by disking 800 to 1000 pounds of calcium cyanamid per acre into the surface 3 or 4 inches. The soil must be moist. Planting should be delayed until thirty days after the soil treatment. This material will supply 160 to 200 pounds of nitrogen so the fertilizer application must be reduced accordingly.

CHERVIL.

(Anthriscus cerefolium.)

As a substitute for parsley this vegetable deserves a place in the garden. The leaves are used for garnishing and seasoning salads. They are sweeter and of a more aromatic flavor than parsley.

Chervil blossoms and soon dies in mid-summer. It should be grown as an early spring or fall crop and, being quite hardy, will exist through the winter with slight protection by straw, leaves or other coarse material.

The seed is drilled in rows 12 inches apart and the plants thinned to 6 to 10 inches in the row.

In six to eight weeks the young leaves are ready for harvesting. The finely curled variety is preferred to the plain or ferned leaved.

CHINESE CABBAGE.

(B. pekinensis and B. chinensis.)

In China this crop has been cultivated for many centuries. Chinese cabbage is a mustard. It is a delicious vegetable, useful as a salad or potherb. The inner blanched leaves are the more desirable part.

A rich loam or muck containing plenty of moisture will give excellent results. The organic matter and fertilizer requirements are much like those of cauliflower.

One can scarcely get the Chinese cabbage to head in the spring even with early seeding outside, or starting under glass. The cool spring temperatures and long days of June will both contribute to flower-stalk development. The fall crop in the North and the late fall and winter one in the South are seeded usually where they are to mature. In the northern range, seed may be planted in July. Further south, August or September will serve. The plants should be thinned to stand 18 to 24 inches apart in 24- to 30-inch rows or 18 inches apart when planted in double rows on beds. It takes about 1½ pounds of seed to plant an acre.

Varieties.—There are two distinct species; the hard-heading type or Pe-tsai and the loose open type known as Pak-choi.

Of the heading sorts there are three varieties commonly offered by seedsmen. The Chihli, also called Surehead or Narrow Head, produces a very tall, narrow cylindical head. Michihli has very uniformly shaped heads of the Chihli type. It has considerable resistance to seedstalk production in the autumn. Pe-tsai develops a head about 18 inches high, which is slightly larger at the top than bottom. Wong Bok is short and very chunky. The non-heading

Pak-choi has dark-green rather smooth leaves with fleshy white petioles. It is often sold as "Chinese white mustard."

Harvesting.—As soon as the heads are firm they may be cut like cabbage. They will keep fairly well in cold storage if mature and carefully handled.

Fig. 50.—Heads of Pe-tsai type of Chinese cabbage.

CORN SALAD.

(Valerianella locusta var. olitoria.)

On the Continent where salad-making is an art, corn salad is employed quite universally. It is known also as lamb's lettuce and fetticus. A rather large rosette of leaves is formed, which can be used as a salad and potherb. The flavor is almost tasteless. Corn salad is served with less mild vegetables such as cress or mustard.

A rich moist soil well supplied with nitrogen must be provided. The seed for the spring crop is sown in place as early as possible. The fall and winter crop can be started similarly in August or September. It may be protected over winter like chervil. Rows are spaced 12 to 18 inches apart and a stand of 5 to 6 inches allowed. The foliage may be blanched by covering with paper or boards before harvest. The whole plants are cut off when large enough. This stage will be reached usually in forty to fifty days.

CRESS.

One of the freshest and crispest of the salad plants, *Garden Cress* (Lepidium sativum) passes often under the name of *Pepper Grass.* A tuft of finely cut leaves is produced. A rich moist loam will grow this crop with the highest degree of quality.

Seed is planted early in the season rather shallowly in rows 8 to 12 inches apart. In three to six weeks the growth is large enough to use, and as some of the plants are removed additional space is provided for those remaining. During the long hot days of summer the plants go quickly to flower. Seeding may be resumed in August.

Some people harvest the young leaves, allowing the plant to remain and produce more. It is probably better to make successive plantings and harvest the whole plant.

The *Upland Cress* (Barbarea verna) resembles watercress. A dense growth of 5 to 6 inches high and 10 to 12 inches across develops. A moist soil is required. Seed is planted in rows 12 to 14 inches apart. When thinned to 4 to 8 inches the plants removed may be used. In seven to nine weeks the growth will be sufficient to permit cutting of the young tender tips. If enough water is applied growth will continue all summer and the foliage will not become too bitter. The upland cress will withstand fall frosts, but is killed in winter, except in mild climates.

The principal pest of the garden and upland cress is the flea beetle.

Watercress (Nasturtium officinale) is by far the most popular member of the group. It is a perennial plant which thrives naturally in slow-running, shallow streams but can be grown in a shady, moist section of the garden. It has roundish leaflets borne on stems which root at the nodes. Stem cuttings or seeds may be used for propagation. These may be planted along a brook, in trenches, a garden corner or in forcing structures. When once established, watercress will multiply unless cut too severely. About seven weeks after sowing seed the compound pinnately lobed leaves will be large enough for harvest. The tips of the branches are cut off about 4 to 6 inches from the end.

ENDIVE.

(Cichorium endivia.)

The culture of endive as a food dates back to early times in Egypt. The flattened rosette of leaves is a little slower than lettuce in reaching maturity. A good fertile soil well filled with organic

matter will help to stimulate rapid growth of high-quality leaves. Irrigation may be necessary at times. On most soils 50 to 75 pounds to the acre of each of the three primary nutrients in about a 1:1:1 ratio will be found profitable. A side-dressing with additional nitrogen is desirable with the approach of cool weather.

Propagation and Culture.—If the plants are started under glass in the spring and transplanted to the garden many will produce seed-stalks. In general endive is seeded in the North from June to

Fig. 51.—Endive may be blanched to improve the quality.

August in rows 15 to 18 inches apart. The plants are thinned to 10 to 12 inches. Surplus plants may be transplanted. In the South and in California it is grown as a winter crop from early fall seedings.

Varieties.—There are two distinct types of endive. The curled fringed type is exemplified by the Green Curled and the lighter colored White Curled. Pancalier is a green curled variety with rose-tinted midribs, while Ruffec has pale green midribs. There are several improved types of Broad Leaved Batavian or Escarole. This latter variety is often used as a potherb as well as a salad. On some markets the curled endives are called "chicory." There has been considerable increase in the growing of endive owing to the popularity of the tossed salad.

Blanching and Harvesting.—When endive is to be used for salad some like it blanched to render the heart leaves more tender and less bitter. The plants should be dry before the process begins, and in rainy cloudy weather there is danger of rot developing in the enclosed leaves. An elastic band or piece of string will serve to hold the outer leaves which are drawn together over the center. In fourteen to twenty-one days blanching should be complete. The plant is cut from the root and untied. When growth is vigorous the dense mass of leaves at the center blanch themselves which is the way most of the commercial crop is handled. An average yield is about 600 bushels per acre.

Insects.—*Aphids* must be controlled at all stages of growth.

FLORENCE FENNEL OR FINOCCHIO.

(Foeniculum vulgare var. dulce.)

The foliage of this plant is dense and thread-like. The edible part consists of the bulb-like enlargement formed by the overlap-

FIG. 52.—A front and side view of a Florence fennel plant.

ping of the broadened bases of the leaf-stalks. This part is crisp, sweet and of an anise-like flavor. It is usually cooked and used alone or for flavoring other dishes.

Cool weather is almost essential for successful growth. Florence fennel should be seeded very early in the spring, or later in the summer for fall use. In areas with mild climates an early fall planting provides a harvest during the winter months. The rows are spaced 18 to 24 inches apart. The young seedlings should be thinned to 4 to 6 inches in the row. When planted in two rows 14 inches apart on a bed for furrow irrigation 6 to 8 inches are allowed between plants. As soon as the swollen base is 2 inches or so across the plant is ready for harvesting. Some growers work the soil up around the bulbous base to blanch it. The over-wintered crop must be gathered before the flower-stalk starts to develop.

Roots and unsightly leaves are trimmed off and several plants tied in a bunch. On some markets this crop is called "anise."

LETTUCE.

(Lactuca sativa.)

Several hundred years before the birth of Christ, lettuce was known and cultivated. Plenty of sunlight, uniformly cool nights and a good water supply are necessary for successful formation of a solid head in varieties of the heading types. Too high a temperature results in elongation of the central stalk or loss of quality. In the northern tier of states a fair crop can be matured occasionally in summer if the right weather persists. A monthly mean temperature between 55° and 60° F. is ideal for heading.

The per capita consumption of lettuce is increasing steadily from year to year. There has been a decided shift in popularity from the head lettuce salad to the tossed salad. The result has been a marked increase in the production of romaine and leaf lettuce. These with endive have taken over some of the market formerly held by crisphead lettuce.

Fertilization.—A sandy loam soil is preferred for the early crop and a silt loam for fall. Muck soil is ideal for lettuce. Regardless of the class of soil, thorough preparation should be given. Root growth is increased in a loose friable soil well supplied with organic matter. Rapid development of the roots is necessary in a quick-maturing crop of this sort.

Animal or green manures are used to maintain a high content of soil organic matter. In addition, depending on the type and fertility of the soil, 50 to 100 pounds of nitrogen and potash per acre with about twice as much phosphoric acid will suffice. As much potash as phosphoric acid is justified on sandy soils. Lettuce may need a side-dressing of available nitrogen about the time of thinning especially during cool weather or when subjected to heavy rainfall. The aim is to produce as large a frame growth as possible

before heading starts. Too much nitrogen coupled with good growing weather may make growth so tender that tipburn will be severe. Growth should be steady but not too rapid.

When lettuce is grown on peat soil which has been newly cleared, the analysis should have little or no nitrogen but be high in phosphoric acid and potash. On peat soils which have been under cultivation for some time, a ratio of 1:2:2 or 1:2:3 at a rate which will supply 25 to 50 pounds of nitrogen per acre, should be satisfactory.

The soil reaction should be brought to between pH 6 and 7 if

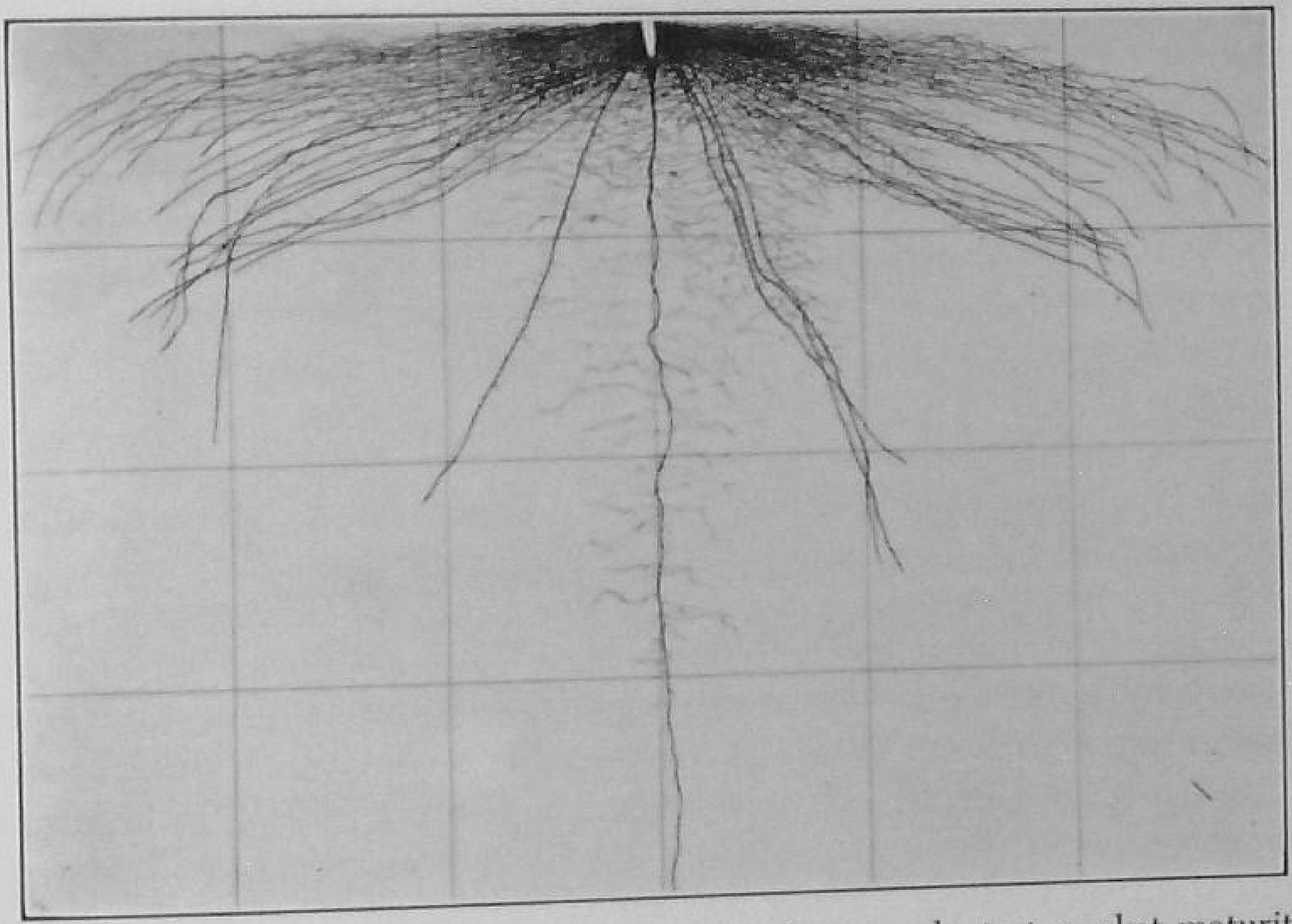

FIG. 53.—The root system of an Imperial 44 lettuce plant at market maturity in a peat soil. All the roots have been brought into a single plane. Each square equals one foot. (Courtesy of Cornell Univ. Agr. Exp. Sta.)

it is more acid than pH 6. Lettuce does well on soils slightly on the alkaline side of neutrality when this state occurs naturally and is not produced by heavy applications of lime.

Propagation and Culture.—In some parts of the East and South plants for a spring crop are started under glass or in beds six to eight weeks before the land can be readied. Most of the lettuce crop is seeded in place using 1½ to 3 pounds of seed to the acre. When the seedlings are an inch or so high they are "blocked out" with a hoe or special machine. If the stand is too thick the spacing job is difficult. Some hand thinning to a stand of one plant every 12 to 14 inches may be necessary. Should the plants be thinned to stand 10 inches or closer, maturity may be delayed and head size

reduced. There is a close correlation between spacing and head size. When lettuce is planted in single rows, 18 inches should be allowed between rows. Under furrow irrigation the two rows on the top of the 20 inch bed are usually 14 inches apart.

In areas where a crop for winter harvest is grown and seed must be planted while soil temperatures are still above 80° F., germination difficulties are encountered with fresh seed. There are four ways to counteract this (1) use seed which is one or two years old, (2) barely cover the seed eight to twelve hours with a ½ of 1 per cent solution of thiourea followed by rinsing and drying, (3) hold moistened seed at 40° F. for four to six days before drying and planting it, or (4) maintain a constantly moist soil which by the cooling from evaporation may keep the temperature low enough to avoid the development of secondary dormancy in the seeds.

The root system of lettuce is such that cultivation should be shallow. Quality will be best if growth is steady. This means that irrigation should be frequent enough to maintain available water in the surface two feet of soil where most of the root growth takes place.

Varieties.—There are four types of lettuce in common use. Within each type the varieties differ widely in their environmental adaptations. Many synonyms are offered by seedsmen.

Butter-head varieties have soft-textured leaves, which are rather smooth. The inner leaves blanch to a golden-yellow. Big Boston which has a brownish tint at the edges, and White Boston are popular on some markets. Bibb is a high-quality variety with small heads.

Crisp-head varieties have coarse-veined more brittle foliage and a white heart. They are sold on the Eastern markets as "Iceberg," but the true Iceberg variety has a red tinting on the leaves.

Imperial 44 and Great Lakes are best for the East and South. They head better and are slower than others to produce seedstalks in warm weather. Imperial 456, a close relative to Great Lakes, but smaller in size, is useful on eastern muck soils. Pennlake does well as an early crop on mineral soils.

In Arizona and California, Imperial 615 or 101 are used for growth during the winter because of their great vigor. They are not suited to warm weather. Great Lakes is used for spring, summer and fall harvest in the West. There are many different strains of Great Lakes varying somewhat in leaf and head characteristics as well as in seasonal adaptation.

Leaf or loose-heading varieties are rather spreading in growth with more or less finely cut and frilled leaves. Black-seeded Simpson will stand more heat than Grand Rapids, while Slobolt is even more resistant to hot weather. Salad Bowl is a new attractive variety.

Romaine or Cos lettuce has a characteristic upright growth with long heads. It is of firm texture, sweet and of high quality. White Paris or Trianon and Dark Green Cos are in general use. Parris Island has some resistance to mosaic.

Harvesting.—The leaf type is cut as soon as large enough, and before it becomes tough and bitter. Heading sorts should be harvested when the heads have become as hard as the prevailing weather conditions will permit, and before the seedstalk develops. The stem is cut at the ground level with a knife or special cutting tool. When the crop is to be packed in the field the cutter removes the old leaves from the base of the head as he cuts it. The heads from several rows are piled together in a long heap from which the packers work. This method is used with the butter-head varieties which cannot be iced, and is used also to some extent with the crisp-head varieties. It is known as the dry pack.

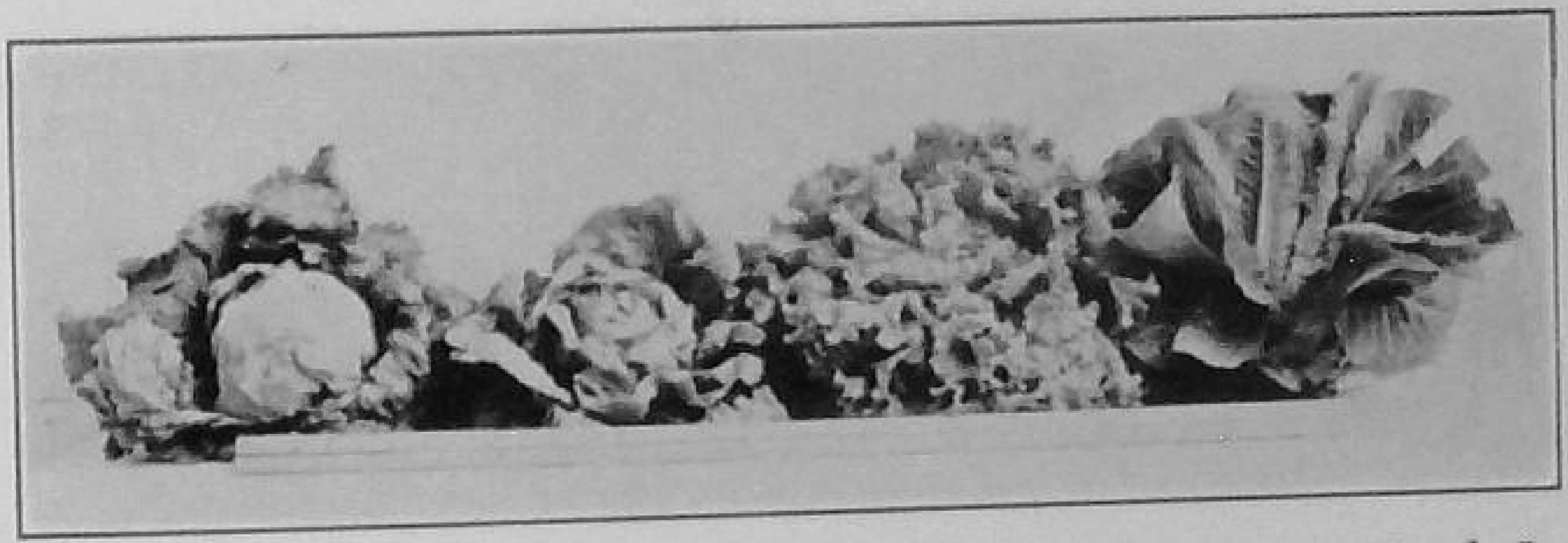

FIG. 54.—Types of lettuce. Left to right, Crisp Head, Butter Head, Leaf and Cos.

Some of the lettuce from large-scale operations is put through a packing shed where it is trimmed. Therefore, in the field, it is merely cut and piled in long rows from which it is placed in field crates or tossed into trucks. Mechanical loaders are used extensively in the West. These move ahead of ten or more harvesters who place the heads as cut on the moving belt which carries them to where they drop into a truck body.

The standard vegetable crate contains 4 to 6 dozen heads. These are packed in three layers with 20 to 30 pounds of crushed ice distributed between the layers and over the top layer of heads. About 5 tons of crushed ice is blown over the top of the load of crates in the refrigerator car which receives also bunker icing. Lettuce will remain in good condition in cold storage for several weeks.

The fiberboard carton pack (2 dozen heads) is lighter than the standard wooden crate. This facilitates ease of handling during the marketing process. These cartons can be filled from windrows of cut heads as in the dry pack method. Machinery is in use on which the boxes are shaped and stapled together as it moves down the

field. The cutters place the trimmed heads directly on the equipment within reach of the packers riding on it. After being closed with staples the cartons move onto a truck which accompanies the loader.

Vacuum cooling instead of crate icing lowers the head temperatures to 32° to 34° F. The vacuum chambers will cool a half carload of cartons in about twenty minutes. The chilled lettuce moves to market with no top icing in the refrigerator cars or trucks.

An acre should yield 150 to 250 crates (four dozen heads each).

FIG. 55.—Cutting lettuce and loading it mechanically at Salinas, California. (Courtesy California Agr. Ext. Service.)

Insects and Diseases.—*Aphids* are the most troublesome insects that must be combated. *Lettuce Drop* results in a wilting and collapse of the outer leaves. Crop rotation is recommended. *Bottom Rot* is serious in damp weather and on the spreading types of lettuce. Improved Ceresan blown under the leaves will check the spread of the disease. When losses occur from *Mosaic,* a special effort must be made to control aphids, as they are probably the means of spreading the virus. *Tip-burn* is a physiological trouble, characterized by the development of a dead margin around the tender leaves. It is most prevalent under hot dry conditions and seems to be due to excessive loss of water following the development of tender growth. Plenty of soil moisture and avoidance of overfertilization reduce losses. *Downy Mildew* can be partially controlled by eradication of wild lettuce and by rotation. There is no practical control for *Yellows,* which is spread by leafhoppers, nor for *Spotted Wilt* which thrips spread. *Big Vein* is believed to be caused by a soil-borne virus. There is no good control under field conditions.

PARSLEY.

(Petroselinum crispum)

As a garnish, parsley rules supreme and has been so used since the days of the early Greeks. The leaves from the thick rosette of the first year's growth are employed also for flavoring soups and salads. A rich, fertile soil, well supplied with organic matter, side dressings of nitrogen and plenty of moisture are desirable. The plant is a biennial and produces a seedstalk after being exposed to a month or so of temperatures between 40° and 50° F.

Propagation and Culture.—Parsley is very easy to grow, once the first stages are past. Because of the slow rate of germination of parsley seed and the delicate seedlings produced, it is probably best to sow under glass or in an open seedbed and transplant later to the garden. The plants are hardy so may be set out very early at 6 to 12 inches in rows 18 to 24 inches apart.

Large-scale plantings are seeded directly in the field using 3 pounds or more of seed for rows 18 to 24 inches apart on the flat, or two rows 12 to 14 inches apart on beds for furrow irrigation. With proper adjustment of the seeder, the plants will be scattered enough so no thinning is needed. On small areas the plants could be thinned to stand 6 inches apart in the row. Pre-emergence sprays are very useful in preventing weed competition. Special herbicidal oils can be used to kill weeds in the growing crop as long as they are not applied within a month of harvest.

Varieties.—The curled-leaf parsley is the most attractive and is offered under several variety names, differing in the degree of curling. The fern-leaved is similar but not curled. The plain-leaf parsley is grown but little and then usually for flavoring. The Hamburg or turnip-rooted parsley is a dual purpose vegetable. The tops resemble the plain-leaf variety and are similarly used. A white root some 8 or more inches long develops. This can be stored like other root crops. The plants are harvested more commonly perhaps when but partly grown and bunched for sale.

Harvesting.—In about three months from seeding, parsley is large enough so that some of the outer leaves may be cut off and tied in small bunches for sale. Harvesting continues as rapidly as new growth appears until severe frosts in the fall. Medium-sized roots can be potted for the kitchen window or transplanted to the greenhouse or coldframe. Leaves may be dried and kept for winter use.

An acre should yield 1,000 dozen bunches at each cutting. From 2 to 5 harvests are possible for each planting depending on the time of year the seeding is made and the seasonal conditions.

WITLOOF CHICORY.

(Chichorium intybus.)

Although the dry roots of chicory are used ground as a substitute for coffee, the witloof type is known more widely as a winter salad, popularly called "French endive." It is a relative of the garden endive but quite distinct.

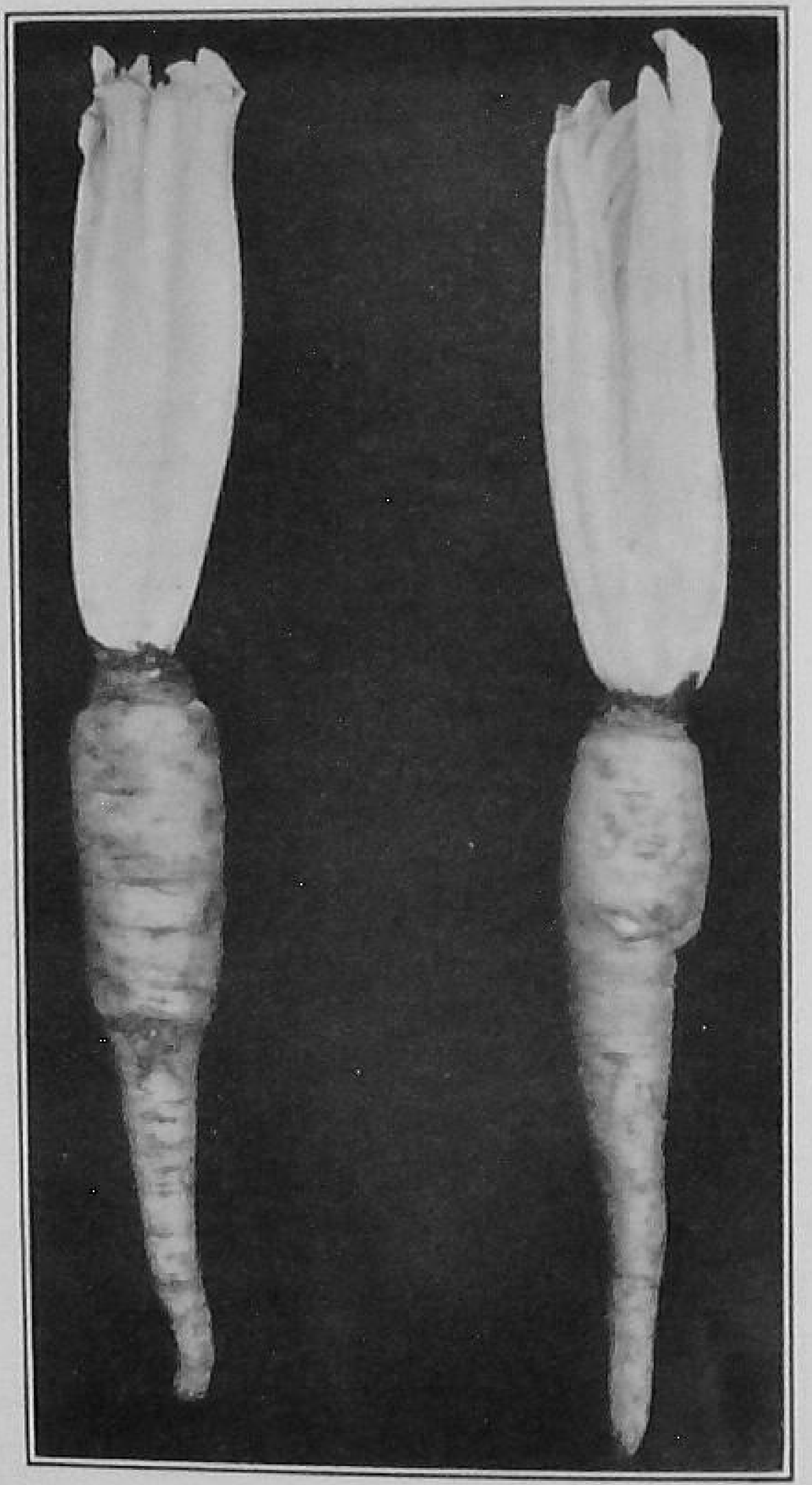

Fig. 56—Roots of Witloof chicory which have been forced to produce the blanched heads.

Any good, fertile soil will produce satisfactory roots. Seed is planted in June. If sown too early the roots will be larger than the desirable size of 1 to 1¾ inches in diameter. The rows are spaced wide enough for clean cultivation and the plants thinned to 5 or 6 inches in the row.

Late in the autumn the roots are plowed or forked from the soil. The top growth is cut off 2 inches above the crown. At this time

all overgrown roots 2 inches or more in diameter may be discarded. These give compound heads which are all right for home consumption but scarcely marketable. Plants which have produced seed-stalks should be discarded also. The roots can be stored in a cool moist cellar until needed, but should not be allowed to freeze.

Forcing.—The roots can be forced at any time that they are large enough. If they are stored five months or more a seed-stalk may be produced instead of a marketable head.

Medium-sized roots of 1- to 1¾-inch diameter produce the heaviest yields. The tips of the roots can be cut off so that they are about 8 inches in length. The roots are placed upright about an inch apart in boxes or beds and moist soil filled in around them up to the level of the crowns. The soil is watered thoroughly and this should be all the moisture that is required while the crop is growing.

To produce compact heads an 8-inch layer of dry sand is placed over the crowns a day after they are bedded. Little rot will occur. For home use no sand covering is necessary. Light is excluded and the blanched leaves plucked off as soon as they are large enough. A greater yield from each root can be obtained in this way. The product in this case resembles the barbe-de-capucin, ordinarily obtained with the less improved varieties.

The market desires a compact head 5 to 6 inches long and weighing 2 to 3 ounces. The true witloof variety should be used if such heads are desired. It is sweeter and less bitter than other varieties.

The rate of growth is proportionate to the temperature, which should be about 60° F. It will take three weeks, usually, for the heads to break ground.

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Chapter 21

THE BULB CROPS

THE members of this group are closely related botanically and quite similar also in their cultural requirements. They are hardy and make their best growth under cool, moist conditions. Their habit of growth is rather erect, which permits relatively close planting.

They are crops of considerable antiquity. While in the wilderness, the Hebrews lamented to Moses concerning the lack of onions, garlic and leek.

CHIVE OR CIVE.

(Allium schoenoprasum.)

Many family gardens have clumps of this hardy perennial. The small leaves are hollow and somewhat grass-like. At the base they thicken to a slight bulbous enlargement. The leaves are cut as needed for seasoning. The Scotch consider them desirable in omelettes.

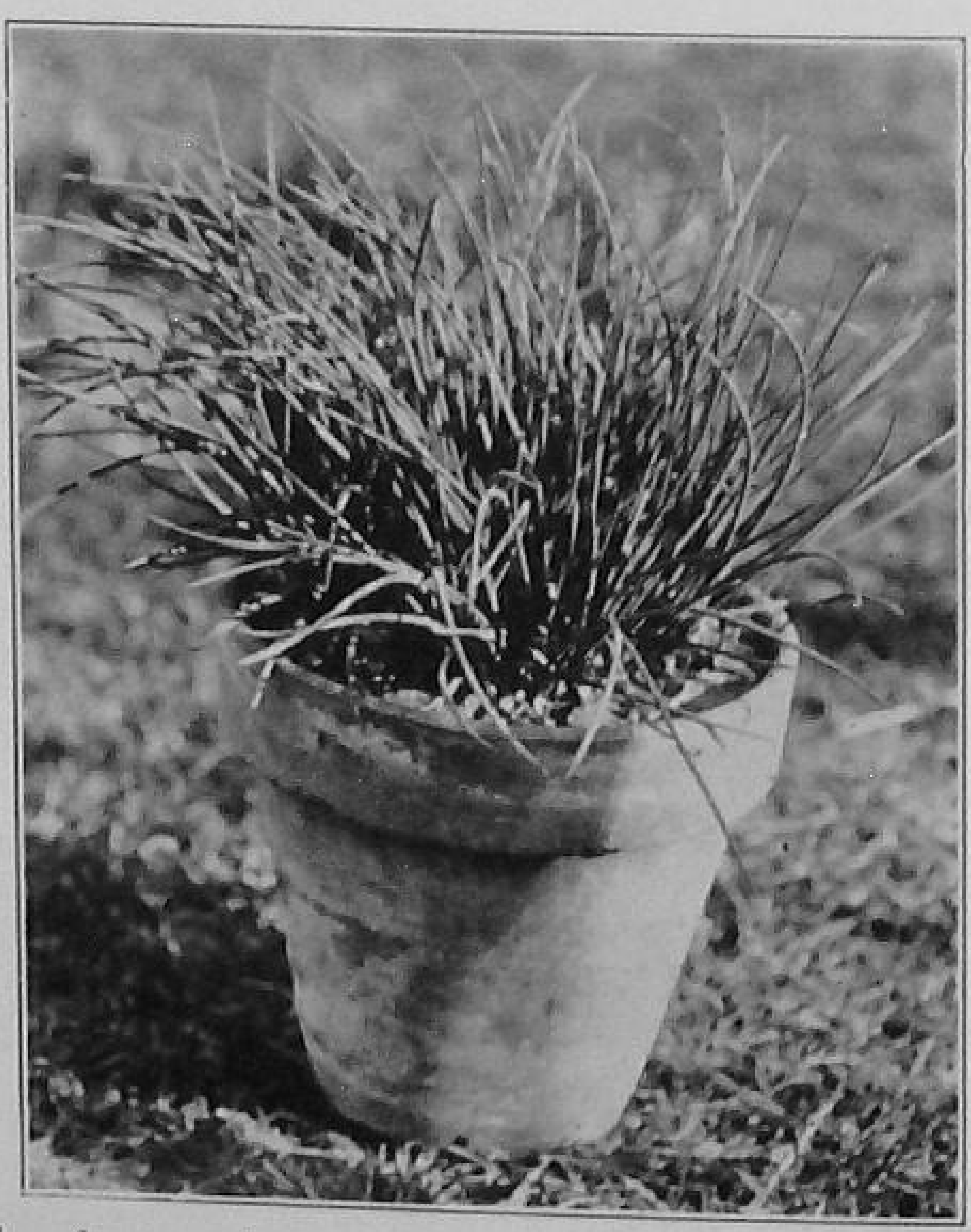

FIG. 57.—Chive develops a clump of small onion-like leaves which are used for flavoring. (*The Country Gentleman.*)

Propagation.—Chive plants bloom in the summer but produce seed only under certain environmental conditions. Seedsmen carry chive seed with which one may make a start. After that propagation is by means of division of the clumps of plants. It is well to do this every few years in order to maintain a thrifty growth. Potted clumps are found sometimes on the market in the autumn for the housewife to grow in the kitchen window during the winter months.

CIBOUL(E) OR WELSH ONION.

(A. fistulosum.)

A hardy perennial adapted for the production of early green onions. Its habit of growth is similar to the chive but the size of leaf is more like that of the onion. There is but little swelling at the base. The plants are mild in flavor and useful for seasoning or as green onions.

Propagation.—Propagation may be by division of the plants, or by use of seed. This may be drilled in the row in April for summer harvest or in August for overwintering. The seeds can be placed in a 3- or 4-inch trench and soil filled in gradually about the seedlings. A greater length of blanched portion is obtained and protection given the overwintered plants. This onion is listed sometimes as White Welsh, Nebuka or Japanese Bunching.

GARLIC.

(A. sativum.)

A compound bulb contains the edible product of this crop. The group of small segments or cloves is surrounded by a thin white or pinkish sheath. The flavor of the cloves is more powerful than that of the other bulb crops. The foliage is flattened rather than hollow like the onion.

Like the onion, garlic develops bulbs in response to lengthening days in the spring, but unlike onion it must first have a period of exposure to cool temperature in the ground or storage for the day-length to be fully effective.

Most of the commercial crop is grown in the central coastal area of California which has a mild winter climate. The Early or Mexican variety has relatively few, large soft cloves and is planted in October. The Late or Italian variety, with many small firm pink-skinned cloves, is planted in November and December. Where the ground freezes planting must be delayed until spring which reduces the size attained by the bulbs.

Silt or clay loam soils are best. Garlic should be fertilized as onions would be on the same soil.

The cloves are pushed into the soil at 3 inch intervals in rows 18 to 24 inches apart on the flat or 12 to 14 inches apart on low beds. Irrigation is not practised if it can be avoided as too much water in the soil causes the sheath which encloses the cloves to become discolored.

When the tops turn yellow in early summer the bulbs are loosened with a cutting tool, pulled, and cured in windrows until dry. Then the tops and roots are trimmed off by hand. The bulbs are usually sacked for storage and sale.

LEEK.

(A. porrum.)

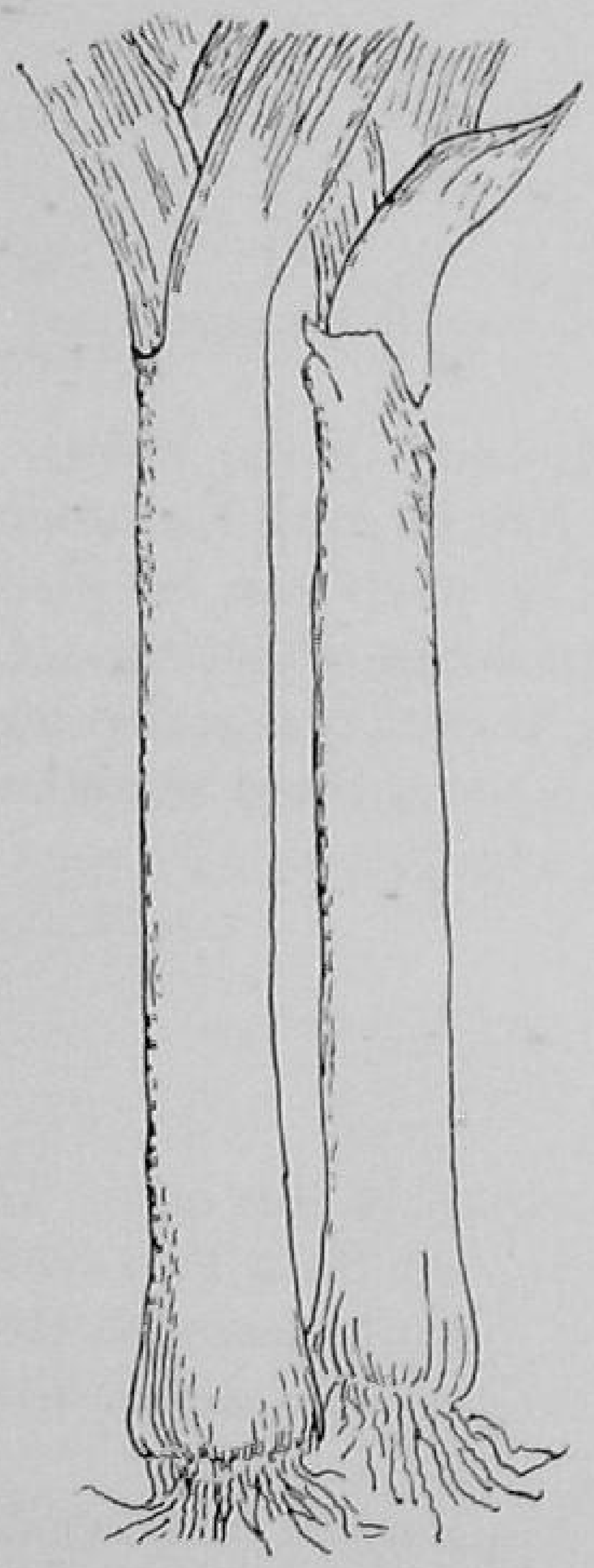

FIG. 58.—Long blanched stems of leek resemble green onions. (Boyle.)

Emperor Nero made the leek historically famous when he earned the nickname "Porrophagus" or "leek-throated," because of his habit of eating them at fairly regular periods to improve his voice.

Leeks are quite mild in flavor, and used raw, cooked or as flavoring. The leaves are rather thick and flattened. The base is swollen but little. A very rich soil, well supplied with humus, is desirable for best growth. Lime should be added if the soil is very acid. Seed only is used in propagating this biennial. It may be drilled in 12- to 18-inch rows and the leeks thinned to 4 to 6 inches in the row. Some prefer to start the young plants in a seedbed or frame. These are transplanted to the garden in June or July. A whole season is necessary for the leek to complete its growth.

There are two types. The Large American Flag is the most popular variety. It is taller but somewhat smaller in diameter than the other group, which includes such varieties as the Giant Carentan.

The quality of the leaf bases is improved by blanching, which begins only after the plants are pretty well grown. It is easier to draw the soil to the plants if they have been planted in a 6-inch trench, but weed control will be found more difficult. The blanched portion of the plant should be 6 to 8 inches in length and 1 to 2 inches in diameter.

Just before freezing weather the plants can be pulled, bunched and sold like green onions, or dug with their roots on and planted close together in some sort of storage. They may be kept for two to three months and then used. The temperature should be held rather close to freezing and the soil about the roots moistened as often as necessary to prevent wilting. It is possible to pull leeks, trim off the roots and old leaves, and then hold the product in cold storage for several months.

ONION.

(A. cepa.)

The culture of the onion by man probably dates back as far as any other of the vegetables. It is a crop which requires cool, moist weather, particularly during the early period of growth. If the soil is too dry the secondary roots will fail to develop from the plate at the base of the bulb and reduction of growth results. As the onion matures, fairly warm, dry conditions are desirable. Alternate wet and dry periods may increase the percentage of split and double bulbs.

Fertilization.—A high degree of fertility is essential for large yields because of the limited feeding range of the roots. The condition of the soil appears to be of as much importance as the class. Sandy or silty loams well supplied with organic matter are preferred in the South and parts of the North. A soil which bakes before the seedlings are well established is undesirable. Much of the dry bulb crop for winter storage is grown on muck in the North. This class of soil is almost ideal for onion production.

A level seedbed relatively free from stones and trash and worked up into a moist, friable condition will enable the grower to obtain a better stand. Freedom from weeds is an advantage.

Manure is highly satisfactory at the rate of 15 to 20 tons to the acre on mineral soils. Well-rotted manure is preferable. Heavy manuring of the land for several years previous to its use for onions is a good procedure. Onions grow best at a soil reaction between pH 6.0 and 6.5 on mineral soils; pH 5.5 and 6.5 on muck.

When used with plenty of manure, the fertilizer application should supply 50 to 75 pounds each of nitrogen and potash with 100 to 150 pounds of phosphoric acid, according to the type of soil and its previous fertilization. If the manure is scant, then 100 to 125 pounds of each of the three important nutrients are desirable. Nitrogen side dressings made after the onions commence bulbing may interfere with proper bulb development. The aim of the fertilizer program is to obtain as large a top growth as possible before bulbing starts.

It has been found in California that about 100 pounds each of nitrogen and phosphoric acid to the acre should be applied in bands about 4 inches below the surface of the bed directly under the seeded or transplanted row. Drilling the fertilizer into the shoulders of the bed is the next best location.

On peat soils an analysis with a 1:2:2 to 1:3:5 ratio should be applied at a rate to supply 30 to 60 pounds of nitrogen. Onions on newly cleared peat or muck soils should receive less nitrogen but more phosphoric acid and potash than on organic soils which have been under cultivation for ten years or more. Copper sulphate improves the color and keeping quality of onions on some muck soils.

Propagation and Culture.—The onion is propagated by one of a number of means according to the expected use of the product. In general earlier plantings give larger yields, probably because a greater growth of tops is obtained before bulbing is initiated by the long day-length and high temperatures of early summer. Onions may produce seedstalks the first year if temperatures are too low during early growth. This occurs especially with the plantings grown through the winter for spring harvest.

Seed may be drilled in place as early as the ground can be worked. In the South this may be late fall or early winter. Thinning is a laborious operation so it is better to determine the germinating power of the seed, adjusting the thickness of seeding according to this and the condition of the soil. In muck fewer deformed bulbs are caused from too thick a stand because they may crowd one another out of the way.

The rows can be spaced 12 to 24 inches apart, according to the methods of supplying moisture and the cultivating tools to be used. A depth of ½ to 1 inch is sufficient with the soil moisture content of early spring. The plants may stand 2 to 3 inches apart in the row. Split bulbs occur at wider spacings. The use of 3½ to 4 pounds to the acre of good seed will give a stand that will not need thinning. For the production of pickling or boiling onions, 10 to 15 pounds of seed to the acre are used to give such a close spacing that few develop to large size.

Dry sets will produce bulbs which mature earlier, and are usually of larger size. Therefore, they are preferred to seed for planting the dry-bulb crop in the South and to an increasing extent in the North. Because of their rapid early growth they make a desirable green onion in a short time. The white varieties are best for green onions and if planted several inches deep a long neck can be secured. The sets will not withstand winter freezing. It takes about a quart of sets to plant 70 to 100 feet of row or 10 to 20 bushels for an acre depending on the size of the sets. The little

bulbs are "stuck" or pressed into the ground. They should be 1 to 2 inches apart for green onions and 3 to 4 inches for large bulbs. Machines are available for planting sets.

Dry sets are obtained by very thick seedings using 60 to 100 pounds of seed to an acre or 1 pound to 100 feet of row. Seeds are sown in a band 3 or 4 inches wide. The keen competition between the plants reduces the size of bulbs, and results in a maturing or dying of the tops in summer. The bulbs are lifted, topped, dried and stored until spring on screen or lath-bottom trays in a cold dry place. A diameter of ½ to ¾ inch is the best size. Larger bulbs are more likely to send up a seed-stalk when planted. If the sets are stored at 32° F. the percentage of seedstalks will be less, even among the larger sized sets, than if they are stored at a higher temperature.

FIG. 59.—Sets of multiplier onion, garlic and the single bulb onion. Note the remains of the tissue envelope which separates the garlic cloves.

The Egyptian or tree onion sends up a stalk which forms a cluster of small bulbels or sets at its apex. Sometimes flowers also appear in these clusters. The bulbels are removed from the stalks before they produce leaves. The underground bulb is small. Top-sets will be produced for several years from a single planting if undisturbed. The sets are very hardy, and may be planted in September for green onions the following spring.

The potato or multiplier onion seldom produces seed. The mother bulb splits into segments which are hardy and can be planted in autumn for early green onions. Yellow and white varieties are available.

Seedlings, also called "transplants" or "green sets," are increasing in popularity as a means of starting the crop. They require somewhat greater care in planting than sets, but are extensively used where labor is cheap. The Bermuda and Spanish types of slicing

onions are grown mostly from green sets. The production of these onions is centered in the Southwest. Many field-grown seedlings are shipped annually from Texas for planting in the North. They may be started under glass in the North ten to twelve weeks ahead of field planting with the aim of having them about as thick as a lead pencil by that time. They must not be seeded too thickly. When ready for the field they can be laid in a small furrow, the soil turned over the roots and firmed, or they can be set in holes made with a dibble.

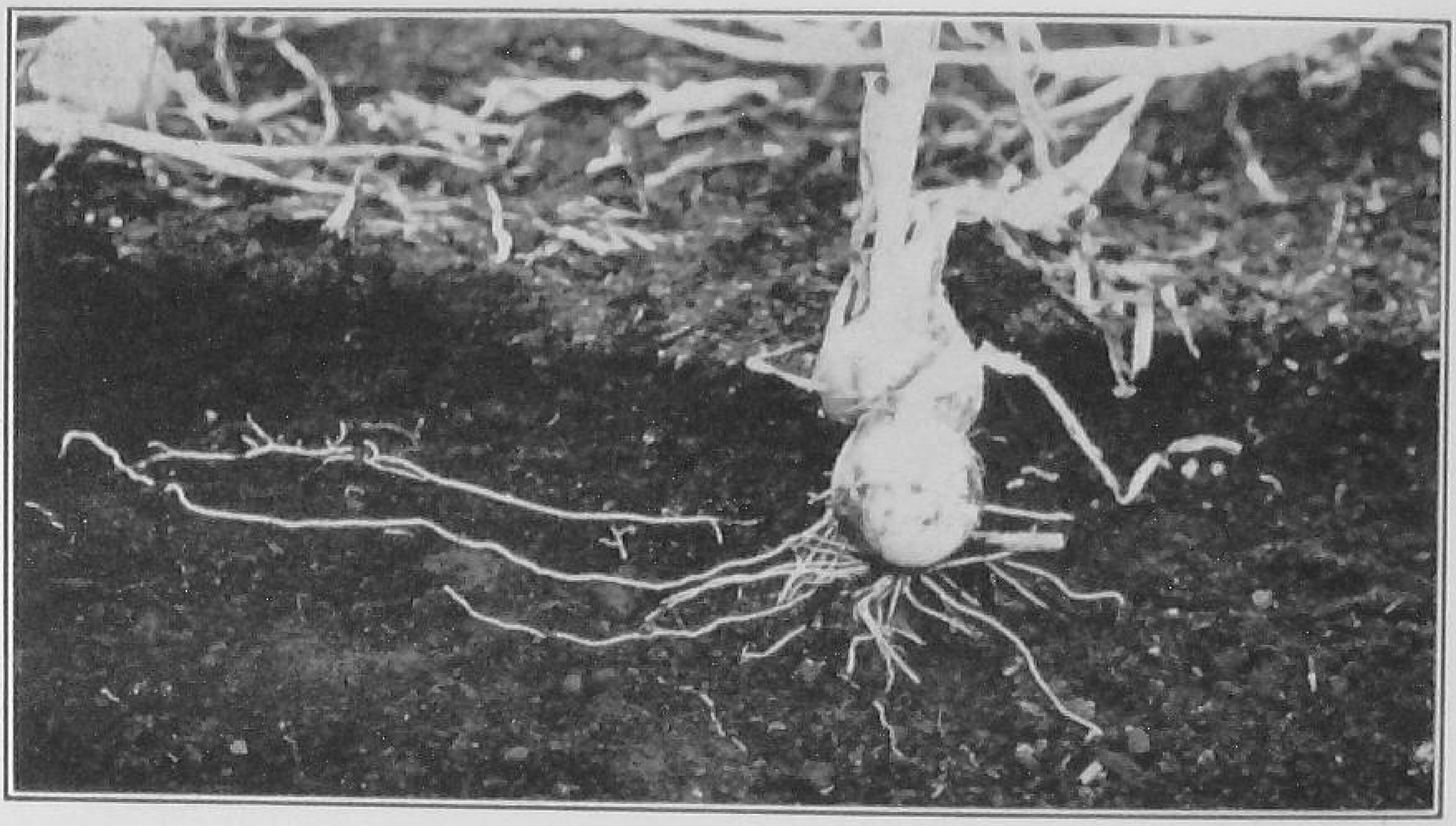

FIG. 60.—Two inches of soil have been removed to show the roots. Cultivation on the left has been at a depth of ½ inch, while on the right severe root pruning has resulted from cultivation which loosened the soil to a depth of 2½ to 3 inches. (Courtesy Cornell Univ. Agr. Exp. Sta.)

The early and midseason crops in Texas, Arizona and California are grown from transplants. These are started in September by planting 25 to 100 pounds of seed to the acre in the plant bed. The seed is scattered in 3 or 4 inch bands by means of a special shoe on the drill. The plants are lifted before they grow too large and set by hand in the field during November to January depending on the area. The tops of the beds can be marked to indicate the position of the transplants at 3 to 4 inches in two rows 8 to 10 inches apart. Clipping of either the tops or roots may reduce the yield, but it is done sometimes to facilitate handling. The roots are pressed into the soil or a hole is made first with a dibble. Irrigation follows promptly. It has been found that by placing the seed an inch or deeper in the soil of the plant bed the transplants produced from the heavier seeding rates will have long, firm shanks. This helps in field setting.

Weed Control and Irrigation.—The onion has a shallow, compact root system. As growth continues each new root arises nearer the surface of the soil. Any root pruning by cultivation reduces bulb growth. When weather permits a pre-emergence spray with herbicidal oil will clear the soil of the weeds which come up before the onions. After the onions are up, a 2 per cent sulphuric acid spray under humid conditions and a Sinox spray in drier areas have given effective weed control. Potassium cyanate (1 pound in 12 gallons of water) has been recommended for killing weeds in onions that are less than six inches high. When the onions are taller, a 2 per cent solution of this cyanate (1 pound in 6 gallons) can be used. Cyanate should be applied when the weeds are dry and the temperature is 75° F. or above. Several hours of dry weather should follow for best results.

Rain or irrigation should come often enough to maintain available moisture in the surface foot of soil where most of the roots are located.

Varieties.—There is considerable variation between onion varieties in their size, color, shape, firmness, keeping quality and length of growing period. The yellow types are preferred to the red or white on most markets.

The season of production of onion varieties is dependent largely on the daylength at which they commence bulbing. Usually warm temperatures will hasten the response to daylength and are necessary for proper maturation of the bulbs, while cool temperatures tend to delay bulb initiation even though the daylength is adequate.

Thus Excel, Texas Grano, Crystal Wax, Yellow Bermuda, Red Creole, and White Creole will commence to bulb at about a 12-hour day. Crystal Grano, San Joaquin, California Early Red and California Hybrid Red No. 1 (a F_1 hybrid) require about thirteen hours. This means that these should make considerable growth during the short winter days, otherwise the small tops which would be developed by the time the suitable daylengths were reached in the spring would give rise to very small bulbs. Any variety which must grow through the low temperatures of winter needs to have some resistance to premature bolting. Ebenezer which is primarily grown from dry sets needs a thirteen-hour photoperiod.

The other varieties in use are generally grown from seed planted directly in the field. They require from thirteen to more than fourteen hours of daylength for bulb initiation. Sweet Spanish, Early Yellow Globe, Mountain Danvers, Australian Brown, the Red, White and Yellow Southports, Red Wethersfield, Yellow Globe Danvers and Yellow Flat Dutch are in this group.

A technique has been developed for producing first generation hybrid varieties by having male sterility in one parent. The bulbs

of such a hybrid are very uniform in size and time of maturity. A number of these hybrids have been named and may replace some of the old varieties.

Most varieties which bulb under the shorter daylength are mild in taste and poor keepers. They make good green bunch onions. Creole, Ebenezer and the varieties which need a long photoperiod are pungent, firm fleshed and adapted to storage.

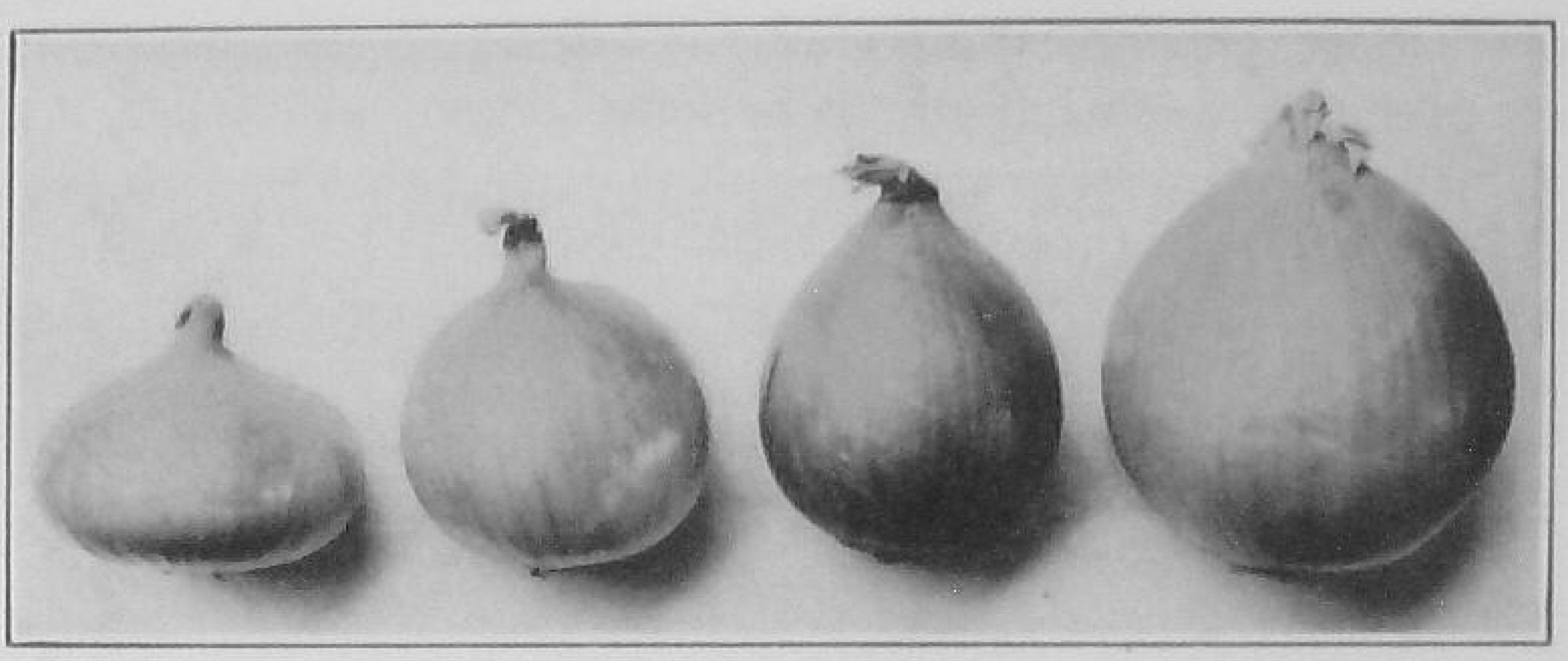

Fig. 61.—Onion varieties, reading from left to right: The Flat Dutch, Yellow Globe Danvers, Southport Yellow Globe, and Sweet Spanish. Note the well-matured necks.

Harvesting and Storing.—The Bermuda onions are harvested as soon as they are large enough, but a variety which is to be stored must be mature. When 60 per cent of the tops have ripened at the neck and fallen over the bulbs may be pulled from the row. A U-shaped lifter such as described for spinach is an aid. The onions are laid in windrows for a few days to dry the tops. The tops are severed ½ inch above the bulb with a topping machine, shears or knife. The curing is completed in crates or open mesh bags. It may take from a few days to two weeks, depending upon the weather, until the outer skin of the bulbs will have become dry and brittle. Onions will not keep well in storage unless properly cured.

The bulbs are passed over a slatted grading table which separates the various sizes. The U. S. No. 1 grades specify size in addition to quality and condition The bulbs must be 1½ inches in diameter with certain percentages above 2 inches depending on color, except where the lot is classified as boilers (1 to 1⅞ inches) or picklers (less than 1 inch). Sweet Spanish bulbs are separated into larger diameter lots. Yields of more than 400 to 500 bushels or 50-pound sacks to the acre are obtained under good conditions.

A cool (32° F.), dry storage is needed for onions. Sprouting, root development or rotting will occur under improper conditions. MH-40, a sodium salt of maleic hydrazide with a wetting agent, can

be sprayed on onion plants just as the tops start to fall over. This treatment will delay sprouting in storage. Manufacturer's directions should be followed.

Green onions are pulled just as the bulb begins to swell. The outer skin must be peeled off. This stripping is easier if the plants have stood in water for several hours.

Insects and Diseases.—*Thrips* is a minute insect which rasps the leaves and sucks out the juice. The tops turn white, curl and die, so the result is popularly called "blast." Dry weather, and the presence near by of any of the other host crops increase the likelihood of trouble. Repeated applications of a 5 to 10 per cent DDT and sulphur dust, or of a 5 per cent chlordane dust have given good control. Dieldrin, heptachlor, and toxaphene are also recommended.

The *Onion Maggot* is the larva of a small gray fly which lays its eggs near or on the base of the onion plant. Rotation and clean-up of refuse are helpful. A 5 per cent chlordane dust can be placed over the plant row just after emergence, or the row sprayed with ½ to 1 pound of actual aldrin, dieldrin or heptachlor per acre. In both of these treatments 3 to 4 additional applications at weekly intervals are necessary.

Onion Smut appears as black blisters on the leaves or scales of young plants. The spores of the fungus live over winter in the soil, but do not seem to be able to cause infection if the soil temperature is 84° F. or above. Sanitation, use of clean sets or transplants, or the application of formaldehyde solution in the row with the seed are methods of control. A solution of 1 pint of formaldehyde in 8 gallons of water is applied at the rate of 100 gallons an acre or ½ gallon to 185 feet of row. Onion seed can be coated with a methyl cellulose sticker solution (a scant 2 ounces in a quart of lukewarm water) at the rate of ¾ pint to 4 pounds of seed. Then 4 pounds of Tersan is added. Thorough mixing for 5 minutes is necessary. In slightly infested soil 1 pound of Arasan could be placed in the hopper of the drill with each 4 pounds of seed. These seed treatments require that a larger hole be used in the drill than with uncoated seed.

Blight or Downy Mildew appears late in the season, forming a purple mold on the leaves, which soon yellow and die. It spreads in damp weather when days are warm and nights cold. Wide spacing of rows lined up with the direction of the prevailing wind to aid drying; burning of dead tops; and rotation are possible control methods. Weekly application of a 7 to 10 per cent zineb dust in combination with sulphur at 30 to 40 pounds to the acre is a recommended practice.

Neck Rot is more troublesome after harvest and on white onions. The outer scales collapse and tufts of the gray fruiting bodies of

the fungus appear. Sanitation in the field, rapid curing, avoidance of mechanical injury, and adequate ventilation in storage are recommended control measures.

The fungus causing *Pink Root* persists in the soil and retards the growth of the onion plants. Granex, a hybrid in the short-day group, as well as some of the other new hybrids have considerable tolerance to the disease. Eclipse, a Crystal Wax type, is highly resistant.

SHALLOT.

(A. ascolonicum.)

This crop is grown principally in Louisiana. Both the pin-leaved and flat-leaved types are used. New leaves arise from the base of the plant each one later developing a long somewhat angular clove. These cloves are joined at their base forming a cluster or clump. Shallots are attacked by thrips and by many of the diseases common to onions.

The dry cloves or sets that have been harvested in late spring and stored in a well-ventilated building during the summer are set in the field about the first of September. Another planting of sets is usually made a month later. These two serve for the early market crop and also as a source of green transplants for one or two later plantings.

The dry sets or the green plants from divided clumps are planted in hills 6 to 8 inches apart using more than one to a place if they are small. The space between the rows varies from 3½ to 6 feet depending on the type of equipment used.

Shallots will usually respond to fertilization with an analysis having a 1:2:1 or a 1:3:1 ratio used at a rate to supply about 30 pounds of nitrogen to the acre. Sidedressing with 15 pounds of nitrogen per acre is desirable once or twice during the winter months.

Beginning five weeks before harvest the plants are blanched by ridging with 4 inches of soil. This is done in two operations at the same time the plants are given shallow cultivation.

Louisiana Pearl is a valuable variety. Louisiana Evergreen, a cross between Pearl and the Nebuka (Japanese Bunching) onion, is useful for local markets as it grows throughout the year never coming to maturity.

After lifting, the shallots are skinned, washed and tied in bunches for shipment to market. The average yield per acre is about 600 dozen bunches or 3,000 pounds. Package icing is necessary to preserve the quality of the tops.

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Chapter 22

THE ROOT CROPS

THESE vegetables are grown for their fleshy below-ground parts and should be provided with a well-prepared seedbed of good depth. Long, smooth roots can scarcely be expected in shallow compacted soil. They are all rather hardy crops, developing best under cool, moist conditions. Certain of them can be left in the ground all winter. Some of them require a whole season for growth, others are quick growing. In the South root-crop culture is confined to the fall, winter and early spring months.

Root crops are quite easy of culture, are planted in rows relatively close together, and are seeded in place except for beets and celeriac, which may be started under glass for transplanting. Horseradish is propagated by root cuttings, not by seed. Cool, moist storage conditions will reduce shriveling of the root crops.

In addition to the crops discussed below the Hamburg-rooted parsley has been mentioned as one of the varieties of parsley in Chapter 20. Considerable acreage of this crop is grown near some of the large eastern markets. Skirret and turnip-rooted chervil belong also in this group. The former has a cluster of small swollen roots, and the latter a short spindle-shaped root. They are of little importance in this country.

BEET.

(Beta vulgaris.)

The garden beet as we know it today was probably not used as a food much before the third century. It is a biennial, producing first a swollen root of varying size and shape from which a flower-stem arises the second year. Although the beet will grow in warm weather it is usually of better color and quality when produced under cool, moist conditions.

Fertilization.—A loose rich loam is desirable for this crop in order to produce shapely roots. The lighter types are good for early beets and those of a heavier nature for the main crop. Muck is excellent. The use of animal or green manures is recommended to obtain proper mellowness. Rotted manure is preferred to fresh, largely because of the danger of introducing weed seeds. Beets should grow rapidly in order to be tender. Commercial fertilizers should

be supplied in the amount and analysis that best fits the condition and class of soil. On most soils beets need from 50 to 75 pounds of nitrogen per acre. If the soil has been well fertilized the complete fertilizer supplying this quantity of nitrogen can have a 1:1:1 ratio. For poorer soils a 1:2:2 ratio is better, while on peat soils a 1:2:3 or 1:2:4 ratio is preferred. In California and Arizona beets may respond to about 50 pounds of phosphoric acid per acre in addition to the nitrogen. Nearly everywhere a side-dressing of 30 to 40 pounds of nitrogen midway in growth is profitable. The internal black-spot or breakdown of beets due to a boron deficiency on neutral and alkaline soils may be reduced by applying 50 pounds of borax per acre with the broadcast fertilizer.

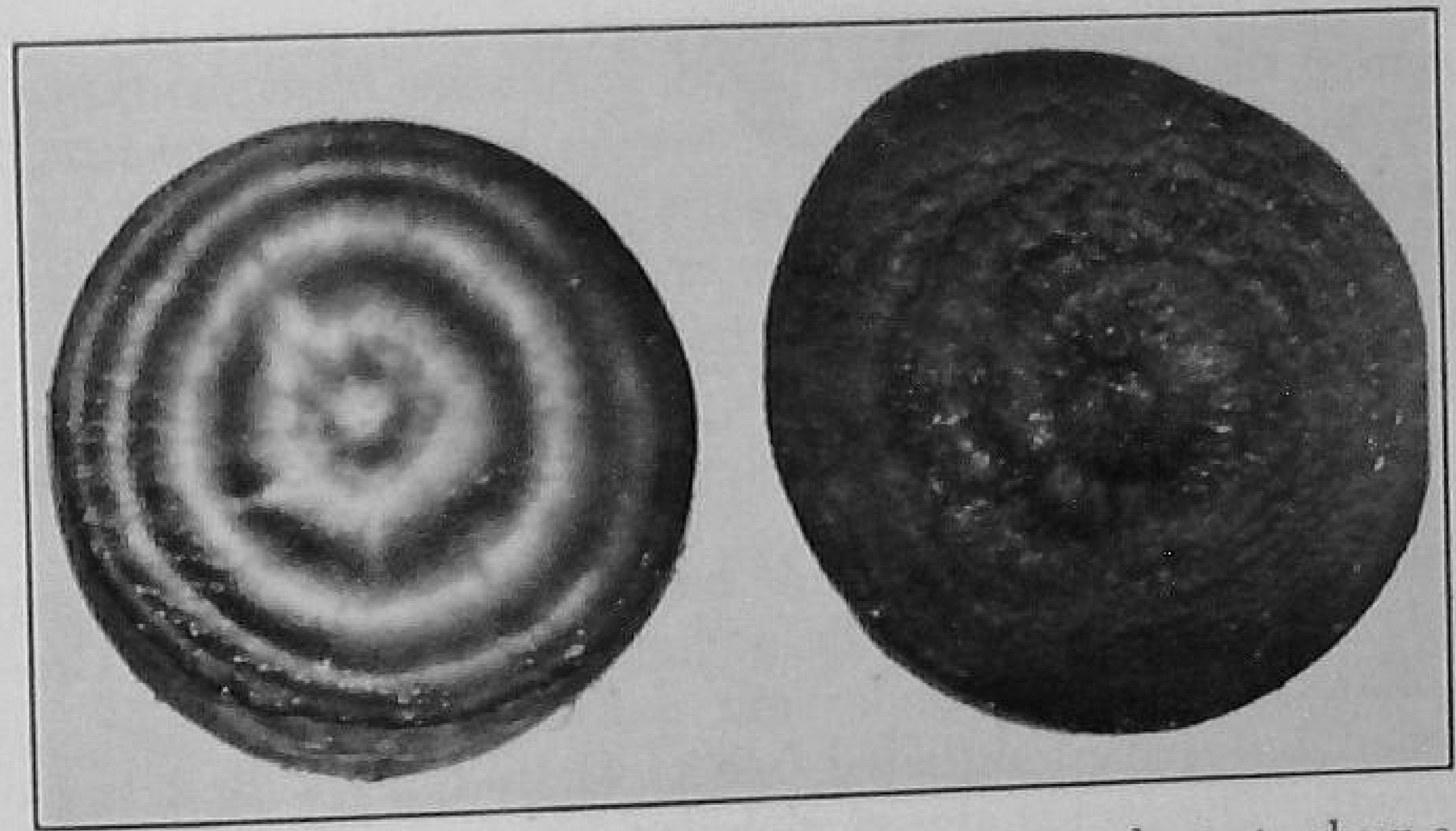

Fig. 62—High temperatures during growth may cause beets to show a pronounced zoning instead of the more desirable solid color. (Courtesy of Ferry-Morse Seed Company.)

Beets have responded in yield on some soils when 500 pounds of common salt to the acre was applied with the mixed fertilizer.

Propagation and Culture.—The beet is half hardy so planting should be delayed a little in those years in which garden operations start at an early date. The corky seed ball of beet is really a fruit containing several seeds. Because of this, the plants will appear in clumps and therefore require thinning. Ordinarily beets are drilled in rows 12 to 18 inches apart. The tops can be allowed to develop to fair size and the thinnings used as greens, or they may be thinned earlier to a 2- to 4-inch interval. If the stand is not too thick the plants may remain until some are large enough to bunch, which will leave room for the rest to develop. It may be questionable whether as early maturity is obtained by this practice. If early varieties are used, successive plantings will provide

a continuous supply. It takes about 10 pounds of seed to plant an acre.

A harvest of early beets may be obtained several weeks ahead of field seedings if plants are started under glass. Several methods are possible; a light seeding to be held in the row until time to transplant to the garden; a transplanting from such a row into flats before field setting; by spotting the seed balls at a 1½ by 1½ inch spacing in the flats to avoid this transplanting; or by seeding and thinning in place for maturity in the hotbed or coldframe. Beet is the only root crop that ordinarily justifies this extra expense. Beet plants to be moved to the field should be started four to five weeks ahead of field setting and hardened somewhat. Hardening should not be prolonged since thirty days exposure of the young plants to an average daily temperature below 50° F. will result in seedstalk formation the first year. Beet plants grown for transplanting suffer heavy losses from damping off. Arasan or Semesan treatment of the seed will reduce this loss greatly.

Weeds in and between the rows in the field must be removed while small. Since beets respond to salt this can be used as a weed killer. When 4 or 5 of the true leaves have formed a spray containing 2 pounds of salt to a gallon of water is put on at the rate of 100 gallons to the acre.

Varieties.—Improvement work has lead to the development of varieties with well-colored flesh and indistinct zoning. Crosby's Egyptian and Early Wonder are quick-growing varieties giving flattened top-shaped rattailed beets. Detroit Dark Red is slower in growth. The root is almost globular with a small tap root. There are strains of these three varieties differing in the length and color of the leaves.

The long and half-long varieties are of excellent quality, but their hairy appearance and lack of uniformity detract from their value as market beets. They require somewhat more time to develop and are seeded in June for fall harvest.

Harvesting and Storing.—Early beets are pulled from the row when about 1½ inches in diameter. If they are allowed to get much larger they become woody, especially in warm, dry weather. Discolored leaves are removed and in case of long-distance shipments all but 6 inches of the top may be cut off. The roots are tied in bunches of 4 or 6, according to their size, but all roots in a given bunch should be fairly uniform. After bunching the beets are washed.

Beets for bulk marketing or canning are topped in the field when the largest have attained a diameter of 3 to 4 inches. They can be held until needed under cool moist storage conditions. An acre should yield about 1,400 dozen bunches of beets or 400 bushels or 10 tons of topped beets.

Insects and Diseases.—The *Leafminer* has been discussed under Swiss chard. The areas of the beet leaves injured by this insect detract from the appearance of bunched beets. It may retard the growth of the plant. Several species of *Webworm* work on beets, principally on the under sides of the leaves. Spray or dust with rotenone for this insect and the *flea beetle*.

Leaf Spot, probably the commonest of beet diseases, can be identified by the shot-hole appearance of the foliage, where the infected spots have turned gray and dropped out. Rotation and sanitation afford the most practical field control. *Curly Top*, a virus disease which is spread by leafhoppers dwarfs the plant. The common *scab* of potatoes may affect beets if the crop is grown on infested soil.

CARROT.

(Daucus carota.)

Although ancient writers mention this root crop, it is questionable whether the carrot as we know it today has been cultivated as a food plant for more than about six hundred years.

The carrot is usually a biennial. The edible root of the first-year's growth contains sugars stored in the outer tissues. Those roots with a relatively small core, *i. e.*, so-called coreless types, are therefore of highest quality.

The carrot is a cool-weather vegetable but can stand the summer heat in the North. Like the beet, it makes a good succession crop. Temperatures below 60° F. may result in pale-colored carrots as is the case sometimes with those grown in the South during the winter.

Fertilization.—The soil for carrots should be deep and loose, particularly for the longer rooted sorts. All classes of soil except the clays are satisfactory. Excellent roots can be grown in muck. Carrots will grow well over a wide range of soil reaction. They can stand a slightly alkaline soil.

A good state of fertility is desirable for tender growth. Organic matter should be incorporated rather liberally to help provide the proper soil texture.

The use of fresh manure which contains considerable urine has been shown to be a factor in causing forking or pronging of carrot roots. Therefore well-rotted manure is preferred if it is to be applied just ahead of the carrot crop.

The fertilizer used on mineral soils in humid regions should supply about 50 pounds of nitrogen and 100 pounds each of phosphoric acid and of potash such as in 1,000 pounds of a 5:10:10 analysis. Additional nitrogen is desirable as a side-dressing espe-

cially in rainy weather. On peat soils an analysis with a ratio of 1:2:3 used at a rate to supply 50 to 75 pounds of nitrogen is desirable. Less nitrogen in relation to the two other nutrients is best on newly cleared peats as for example a 1:3:5 ratio.

In the semi-arid regions of the West and Southwest, the soils contain large quantities of potash. On some soils about 150 pounds of phosphoric acid should be applied as the beds are shaped, while others need half as much or none at all. Nitrogen at the rate of about 50 pounds per acre can be given in one or divided in two side-dressings in bands or dissolved in the irrigation water. This nutrient should not be used liberally in the last half of growth or the tops may be too tall for bunching.

Propagation and Culture.—Carrots are seeded directly in the field. In the North, planting commences in early spring when freezing danger is past, but where the winter climate is mild planting may take place during the fall and winter months. Plantings made at intervals will provide a succession of harvests. Sufficient time must be allowed between the time of the last planting and the usual end of the growing season.

The rows are spaced 12 to 24 inches on the flat or 12 to 14 inches apart when on beds for furrow irrigation. The seed should be planted about a ½ inch deep. On soils which have a tendency to crust from the effect of rain or overhead irrigation, it is necessary sometimes to use a pulverizer to break the crust so the weak seedlings can emerge. Plenty of organic matter in the soil will help eliminate crusting. It is possible to ridge the soil somewhat over the seeded rows so that the ridge may be knocked down later if a crust forms. Carrot seed germinates slowly adapting this crop well to the use of pre-emergence oil sprays for early weed control.

While the texture and structure of the soil are of great importance in the development of straight, smooth roots the thickness of stand is involved also. Thinning is too expensive. Thus the rate of seeding must be carefully judged. Some carrot seeds may have immature embryos which cause delayed germination. Thus there will be variations in root size in the same row due to differences in age. It is best to use a shoe on the drill which will distribute the seed in a 3 to 5 inch band instead of a narrow one. Usually 3 pounds of seed to the acre will give a suitable stand of plants.

It is not necessary to cultivate carrots. A loose condition of the soil should be obtained by the proper choice of the soil, the incorporation of organic matter and in the preparation for planting. Weeds can be controlled by the use of oil sprays. These should not be applied until the seedlings have from 1 to 4 true leaves. Some of the more volatile oils and solvents which are sold for carrot spraying can be used later in growth up to within a few

weeks of harvest. It takes 50 to 100 gallons per acre depending on the size of the weeds and whether the whole area, or just the rows or beds, is to be covered. The carrot plants may be injured by the weed oils if temperatures are above 80° F. Even with chemical control of weeds some growers like to run cultivator sweeps through the field after the roots are partly formed in order to cover the tops of the roots with a little soil. This tends to prevent undesirable greening.

FIG. 63.—Bunching carrots in the field before hauling to the packing shed. (Courtesy California Agr. Exp. Sta.)

Carrots are moderately deep rooted but will not reach proper size or shape in dry soil. Irrigation will be needed to maintain growth if there is no rain.

Varieties.—Imperator is the most important of the varieties used for bunch shipment. It has long cylindrical roots with strong tops. Red Core Chantenay is popular for bunching when partly grown and for storage or processing when more mature. It grows 5 to 6

inches long, rounding at the bottom to a small tap root. Danvers Half Long is somewhat longer with a more pointed root than Chantenay. It is used for storage. Nantes is a high quality, cylindrical blunt-ended carrot with a weak top.

Harvesting.—Carrots are harvested when they reach a diameter of ¾ inch or more. They can be loosened readily if planted on beds by drawing a lifter beneath the rows. On the flat they may need to be plowed out if the soil is firm. Carrots are marketed with and without the tops. Washing improves their appearance.

When sold with the tops they are tied in bunches of 4 to 12 roots depending on size. Those in each bunch must be quite similar in size. Each bunch weighs at least a pound. When crated for shipment package ice is used to preserve the tops and roots.

Many packing sheds are putting 1 pound of topped carrots in transparent film bags at the shipping point. These consumer-sized packages are transported to markets in cartons or crates under refrigeration.

Short-trimmed-top carrots are those with all but 4 inches or less of the top cut off. Snap-topped carrots have all their top removed. These two types are usually sold by weight. Carrots placed in storage are the snap-top type. They may be stored in a cool moist storage. A temperature of 32° to 33° F. is ideal. It has been found that the nutritive value of large carrots is equal if not superior to that of partly-grown carrots.

Yields should average around 12,000 bunches or 400 bushels an acre. On muck yields of 15 to 20 tons an acre are obtained.

Insects and Diseases.—The larva or maggot of the *Carrot Rust Fly* burrows into the root, which may become misshapen or rot if infection follows. When the root is attacked severely the foliage may become rusty or dried. The infection may not appear until the roots are in storage. Parsnips and celery are attacked also. The time of planting may be adjusted so the crop escapes either the early or late brood. Crude naphthalene scattered over the carrots at the rate of 400 pounds to the acre has given good although rather expensive control. Four or five applications are needed at intervals of seven to ten days starting as the flies appear. Dusting the tops with rotenone or chlordane has helped in some cases.

The *Leaf Hopper* which spreads *Aster Yellows* is checked by spraying or dusting with DDT 3 or 4 times at seven to ten day intervals beginning as the migration into the carrots starts.

A *Bacterial Soft Rot* of carrots may develop in storage. Control consists primarily of care in handling during harvest to reduce mechanical injury. *Leaf-blight* diseases cause a browning of the foliage. If the attack is severe the yield may be reduced. Bordeaux, insoluble copper, or the dithiocarbamates are effective.

CELERIAC.

(Apium graveolens var. rapaceum.)

This vegetable is known as turnip-rooted celery or knob celery. The foliage is a very dark green and the plant more dwarf than celery. The cultural methods given for celery apply to this crop. It does not need to be blanched, so may be planted in rows 18 to 24 inches apart. When the swollen root has attained a size of 2 to 2½ inches in diameter the plants may be pulled. The branching roots at the base are cut away and the tops trimmed off, although

FIG. 64.—A bunch of celeriac roots.

sometimes they are bunched. Celeriac can be stored like the other root crops. The flavor of the root is a sort of combination of celery and parsley. The acre yield is 200 to 300 bushels. Celeriac is sometimes used raw in salads but is usually boiled before use.

HORSERADISH.

(Armoracia rusticana.)

This hardy perennial is usually cultivated as an annual. It came into use as a human food, or more exactly a condiment, sometime about the Middle Ages.

Fertilization.—A deep, moist soil underlain with clay is thought to be the most desirable. Heavy applications of well-rotted manure are plowed under well ahead of planting. Some prefer to apply the manure to the previous crop, especially if it is not rotted. Green manures and commercial fertilizers can be used. From 1000 to

2000 pounds of a fertilizer high in potash can be plowed under so as to get it down where the roots will develop.

Propagation and Culture.—Root cuttings or sets are obtained from the crop of the preceding year. These small side roots will vary from ¼ to ½ inch in thickness. The top is cut straight across and the base slanting. The length of set determines the length of the root which will be harvested. Cuttings 8 to 12 inches are preferable but shorter ones will do. These root cuttings are stored in a cool moist cellar or pit until spring.

Furrows 3 to 4 inches deep and 30 inches apart are opened. The sets are laid about a foot apart in this furrow with the apical or

Fig. 65.—Root cuttings at least 8 inches in length are preferred for starting the horseradish crop. (Courtesy California Agr. Exp. Sta.)

straight cut ends slightly higher and pointing in the same direction. Several inches of soil are firmed over the set. The roots in alternate blocks of 10 or 20 rows can point in the other direction which permits round-trip cultivation always in the direction of the tops. Thus fewer plants are torn out. If the roots are not to be stripped the sets can be planted more or less vertically in holes made with the dibble or a rod. A much-branched root is likely to occur, however. The Maliner Kren or Bohemian variety outyields the common variety but processors consider it to be of inferior quality.

Stripping.—In order to obtain smooth roots and avoid excessive branching the cuttings are uncovered when the leaves are about a foot high. The small branch roots at the base must not be disturbed.

The small roots which have started from the sides of the cutting are rubbed off with a glove or rag and all but the best of the crown sprouts removed. The root is recovered with soil. This operation is repeated a month or six weeks later. Although laborious the quality of root obtained justifies the practice.

Harvesting.—Before the ground freezes the roots are plowed out, and the tops twisted or cut off. Cuttings are made from the small basal roots and the main "sticks" stored in a cool moist place or scraped, cleaned and grated with white vinegar. Yields of 1½ to 4 tons an acre can be obtained.

PARSNIP.

(Pastinaca sativa.)

The parsnip has been cultivated since about the time of the Christian Era. It is a biennial, requiring a long-growing period to form the white fleshy root.

Fertilization.—A deep sandy loam is better than a shallow heavy soil for the development of long smooth unbranched roots. Organic matter is important for lightening the soil and preventing the formation of a crust above the seeds. Fertilizer requirements are similar to those of beets and carrots. Parsnip responds to lime on many soils.

Propagation and Culture.—Parsnips planted in early spring in rich soil may grow too large. About one hundred and thirty to one hundred and fifty days are needed to reach good size. Seeding may be delayed until danger of heavy freezes is over.

Parsnip seed is very slow to germinate. The rows may be indicated by mixing a little radish seed with that of the parsnip in order to facilitate early cultivation. Planting sprouted seed may be helpful on some soils. The seedlings are weak and the seed loses much of its viability after a year or two, so that rather thick seeding at a depth of ½ inch is advised. Later the plants are thinned to a space of 3 to 5 inches. The rows are 15 to 30 inches apart depending upon the type of equipment used. Herbicidal oil sprays can be utilized for weed control in this vegetable. A pre-emergence oil spray is very helpful because of the slowness of germination of parsnip seed.

The parsnip is a deep-rooted crop so it draws on a large volume of soil for water. If rain is lacking the soil should be refilled with water by irrigation whenever the available water in the soil begins to get low.

Hollow Crown, Guernsey and Model are good varieties. Early Round is suitable for shallow soils.

Harvesting.—The well-developed parsnip roots are hardy to freezing so may be left in the ground all winter. The roots are plowed out in the late fall and stored in a cool moist cellar or pit. It is not easy to dig them with a fork because of their 10- to 12-inch length. When kept near the freezing-point the starch is changed to sugar, thus improving the quality. The roots are washed for sale. An acre should yield 500 to 800 bushels.

RADISH.

(*Raphanus sativus.*)

The radish has been cultivated since early times, thus ranking with the onion, turnip and a few others in antiquity. A cool moist soil is best for the summer and fall crop. A light loam will aid in early maturity of the spring plantings. Radishes are very useful for intercrop or companion plantings between rows or plants of slower growth. The radish is an annual. Temperature and soil moisture influence root shape.

Fertilization.—High quality of root is dependent upon rapid continuous growth. If radishes are grown as an intercrop the fertilizer treatment for the main crop will be sufficient. When grown by themselves, well-rotted manure plus a fertilizer with a 1:3:1 or 1:3:2 ratio in an amount to supply 25 to 35 pounds of nitrogen to the acre is desirable. Without manure or on sandy soils a ratio of about 1:2:2 is best. The rate of application should furnish 75 to 100 pounds of nitrogen to the acre.

Propagation and Culture.—Radishes are seeded in the place they are to mature. Since the seedlings are hardy, the crop can be started even before danger of heavy frosts is past. If seed of high viability of the spring radishes has been screened into two or more lots each of rather uniform size, fairly accurate spacing is possible. Thus thinning is avoided. The plants should stand about an inch apart. Later types need 3 to 4 inches. Rows may be 6 to 18 inches apart according to the method of cropping and the season of growth. Cultivation is difficult with rows close together, but the crop develops so rapidly that weeds do little harm.

Varieties.—There are three general types of radishes. The quick-growing varieties are ready for harvest in twenty to thirty-five days. They soon become pithy and send up a flower-stalk if allowed to become overmature. Early Scarlet Globe, Cherry Belle, Comet, Cavalier, Sparkler and French Breakfast are more or less globular to olive-shaped. White Icicle and Long Scarlet White Tip are 4 or 5 inches long. Crimson Globe or Crimson Giant holds its quality better in warm weather after reaching edible size. Of the intermediate varieties, Chartier, White Strasburg, with long roots

and Golden Globe with round, are preferred. They develop in forty to sixty days. The third group is called winter radishes since they are adapted to storage not because they grow in winter. They are popular with Oriental people and are known by the general name, Daikon. The varieties China Rose, White Chinese, the Long or the Round Black Spanish and the Sakurajima will reach good size in sixty to eighty days.

Harvesting.—Radishes should be pulled as soon as they reach edible size. The quick-growing and intermediate varieties are tied in bunches of 6 to 12, washed and kept from wilting until sold. Icing helps prevent the rapid deterioration of the tops. About

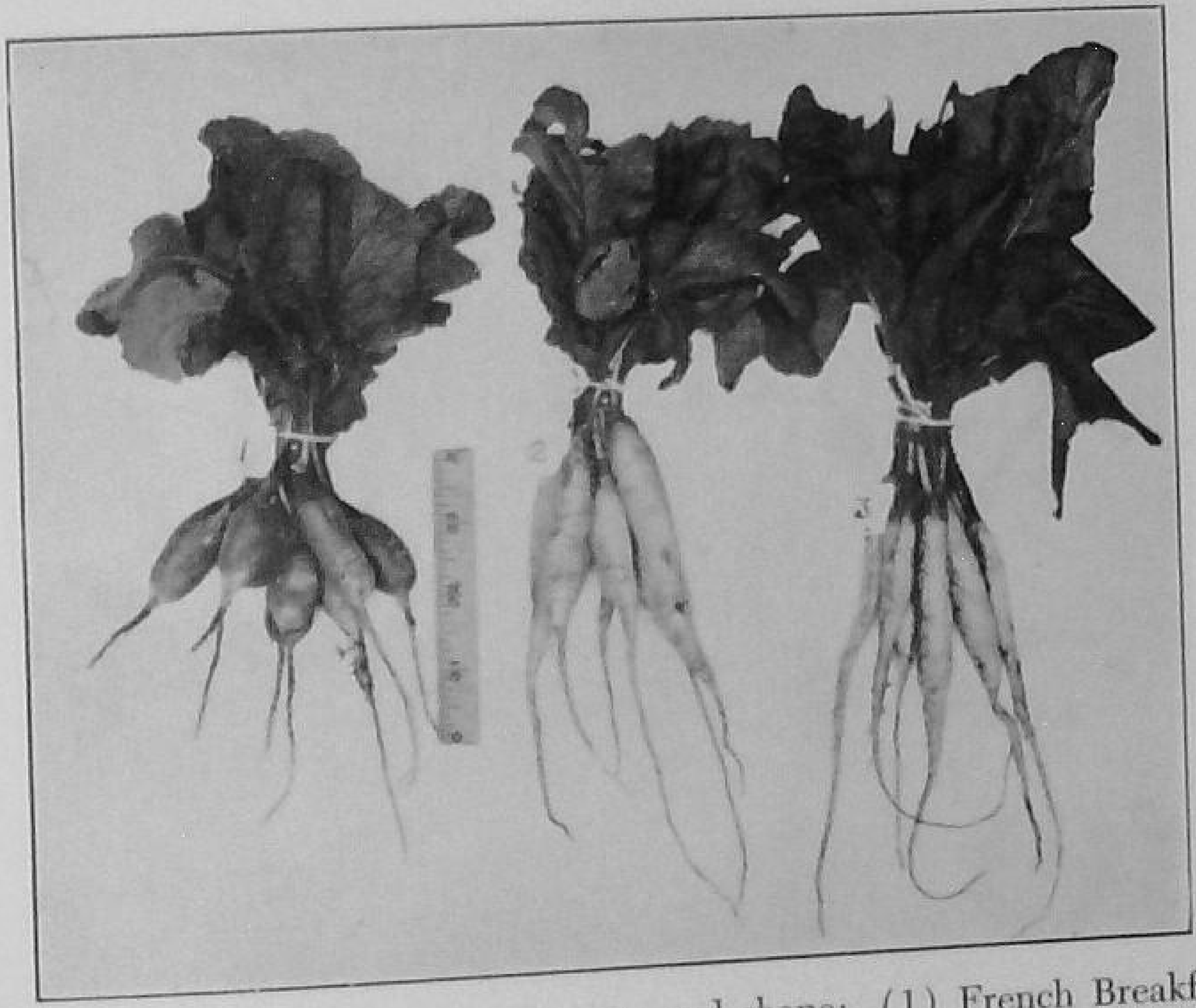

FIG. 66.—Garden radishes vary in size and shape: (1) French Breakfast; (2) White Icicle; (3) White Vienna. (Boyle.)

20,000 bunches can be obtained from an acre. The packaging of 8 ounces of thoroughly-washed topped radishes in transparent film bags is a rapidly-increasing method of marketing. It is possible in this system of preparation for market to lift and top the roots mechanically in the field. Winter radishes are topped and stored like other root crops.

Insects and Diseases.—The only serious insects are *Aphids* and the *Cabbage Maggot. Black-root Disease* is especially severe on White Icicle and worse on late plantings. It is characterized by a deeply sunken black discoloration of the roots, rendering the crop entirely unsuitable for table use. Early planting and the use of red-

globe types on infested soil offer the best control. Under glass, steam sterilization of the soil could well be utilized.

RUTABAGA AND TURNIP.

(Brassica napus var. napobrassica and B. campestris var. rapa.)

These crops are quite similar in their culture. They are biennials but low temperatures may cause seed-stalks the first year. References in ancient writings indicate that the turnip at least has been

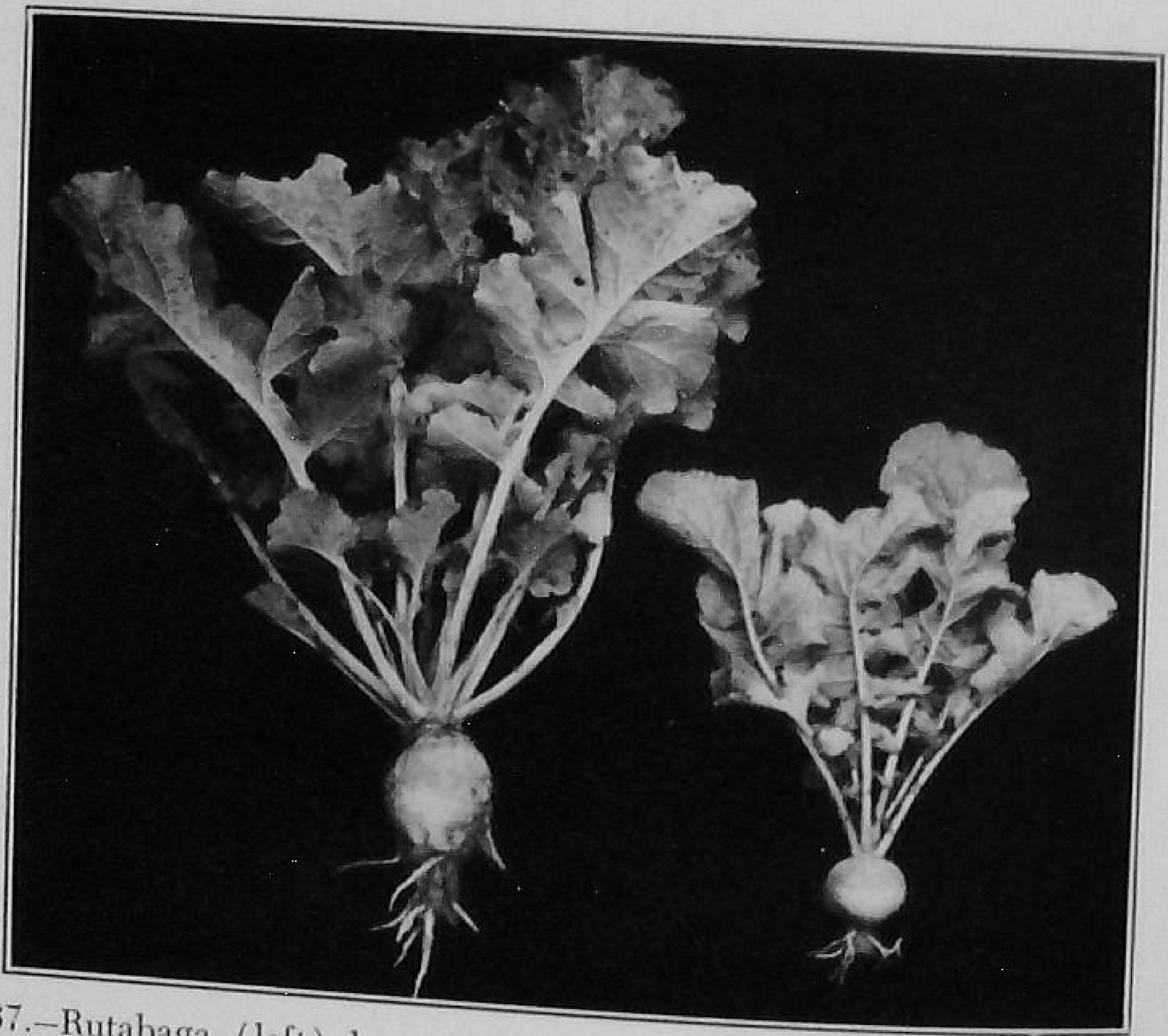

FIG. 67.—Rutabaga (left) has smoother leaves and more fibrous roots than turnip (right).

used by man for four thousand or more years. Many quaint views were held as to the value of the juices or flesh itself in the treatment of various human ills.

The turnip has slightly hairy leaves and a swollen root free of fibrous secondary roots except on the tap-root. On the other hand the rutabaga has smooth leaves and frequently secondary roots arising from the sides of the swollen root. The turnip matures in forty-five to seventy days while the rutabaga requires ninety to one hundred days. The quick maturing types of turnip are grown as a spring crop; the others and the rutabagas are brought to maturity just before freezing weather in the North. In hot weather,

or if grown slowly, the turnip quickly becomes woody, stringy and bitter.

Fertilization.—Rapid, tender growth is produced most easily on a deep, mellow loam, but these crops will grow on poorly prepared land. When grown as a succession crop the fertilizer residues of the previous crop will usually be adequate. If the soil is poor or has not been manured it is well to supply 50 to 75 pounds of nitrogen and about twice that much of both phosphoric acid and potash. With good manuring the phosphoric acid alone will suffice. When turnips grow through the cool, rainy season in the semi-arid West and South, nitrogen should be applied as a side-dressing to maintain vigorous growth. Internal browning of rutabagas is a symptom of boron deficiency which can be corrected by furnishing 15 to 25 pounds of borax per acre.

Propagation and Culture.—In the North turnips can be seeded as soon as the ground can be worked in the spring. The fall crop is started in July. In the South and in those parts of the West where winter temperatures are mild, plantings are made in late summer, fall and early winter. Seedstalk development may occur in plantings which grow through the winter months. Turnips are planted in rows 12 to 18 inches apart. The plants should be thinned to a 2 to 4 inch stand depending on the variety. It takes about 2 pounds of seed to plant an acre.

Rutabagas are grown for fall harvest from June plantings in the North. In warmer sections, plantings should be delayed until later in the summer. The plants should be allowed to stand at 8 to 12 inch intervals in rows 24 to 36 inches apart. About the same quantity of seed is used as with turnips. Rutabagas can be seeded as are turnips two rows on a bed for furrow irrigation.

Varieties.—Purple Milan and White Milan are good varieties for early turnips, Purple Top White Globe, White Egg and Golden Ball make satisfactory fall crops. Shogoin is the best variety for greens as it produces much foliage and a good root. It is somewhat resistant to aphids. Seven-top is used for its foliage only since the root is small and tough. The most popular rutabaga is the yellow-fleshed American Purple Top.

Broccoli-raab, rapa, or turnip broccoli is a rapidly growing annual when sown in the spring, but a biennial in fall plantings. The leaves with the seedstalks, before blooming, are cut for greens.

Harvest.—Turnip greens may be gathered by cutting the tap root just below the crown. Sometimes seedstalks are allowed to develop before the overwintered crop is harvested, but these should not be permitted to bloom. Turnip tops are marketed both loose and bunched.

Turnips may be pulled when about 2 inches in diameter, and tied in bunches of 4 to 6 plants. If the roots are to be topped and sold by weight, turnips are usually allowed to reach a size of 2 to 3½ inches and rutabagas 4 to 6 inches in diameter. Topped turnips and rutabagas will keep well in a cool, moist storage. Rutabagas are waxed in some districts before shipment to market.

Bunched turnips should yield over 5 tons to the acre while topped turnips and rutabagas may produce about 10 tons.

Insects and Diseases.—In hot, dry weather *Aphids* are troublesome. Sometimes the *Cabbage Maggot* will need to be controlled. A Bordeaux film will repel *Flea Beetles. Club-root* and *Black Rot* are controlled as with cabbage.

Fig. 68.—Salsify prepared for market without previous storage.

SALSIFY.

(*Tragopogon porrifolius.*)

The flavor of this crop has earned it the name of "vegetable oyster." Salsify has been used as a food for only a few hundred years. It is a biennial and can withstand winter freezing. A deep, rich soil and long-growing season are the requisites for good growth. Too many lateral roots will form on the heavier soils. The

use of fresh manure is believed to result in forked or branched roots. Lime should be applied if the soil is very acid.

Seed is planted in early spring. The plants should stand 2 to 5 inches apart in rows spaced 12 to 18 inches. Cultivation is given to prevent weed competition. Late in the fall the roots may be dug out, and the tops trimmed back to about 2 inches. A cool, moist storage is necessary. When sold, they are washed and 10 or 12 tied in a bunch. Mammoth Sandwich Island is the variety used, yielding about 300 bushels an acre.

Scorzonera or Black Salsify has a black outer skin. *Scolymus* or Spanish Salsify resembles salsify but is milder and has spiney foliage. Both of these are grown in the same way as salsify except that they should be given somewhat more room for development. All three of these crops are boiled in preparation for eating.

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Chapter 23

BROAD BEAN AND PEA

THESE two vegetables are cool-season crops. The broad bean is more hardy than the pea. Nodules are formed on the roots of both by nitrogen-fixing bacteria. The broad bean develops a sturdy plant while the pea vine is weaker but has tendril-bearing leaves by which it may climb.

BROAD BEAN.

(Vicia faba.)

This bean was well-known to the Egyptians and Romans. It is grown much more commonly in Europe than in the United States. Among growers and on the markets the broad bean is often called the faba or fava bean. Some seedsmen have offered it as a Frost Proof Bean because of its hardiness.

Broad beans do well on most good vegetable soils. Where a complete fertilizer is needed one with a 1:2:1 or 1:2:2 ratio at a rate to supply 30 to 50 pounds of nitrogen per acre will usually prove adequate. Being a legume this bean may develop nodules on its roots which will contain nitrogen-fixing bacteria. It makes a very good soil-improving crop for growth during the winter months in mild climates. Thus it can serve a dual purpose if the market price justifies harvesting the pods.

Planting can begin in early spring as soon as the soil is workable. The crop is started in the fall where winters are mild. From one hundred-twenty to one hundred-fifty days are required to reach the market stage according to the season of the year the crop is grown.

The seeds are planted in single rows 18 to 30 inches apart, or in double rows on beds at 40 inch centers as are lettuce and carrots. In widely-spaced rows a stand of plants at 4 or 5 inch intervals can be allowed, but if the rows are close together it is best to have 8 to 10 inches between plants. About 60 to 100 pounds of seed are needed to plant an acre. Broad bean plants are readily transplanted.

An erect plant 2 to 4 feet tall is produced that bears numerous initially upright pods in the axils of the leaves along the stem. At market maturity, the green shell stage, these slightly rounded pods are about an inch in width and 6 inches or more in length. They

contain 5 or more fleshy beans. The crop can be allowed to mature and the seeds used as dry beans.

Broad Improved Long Pod and Broad Windsor are the varieties usually grown. Varieties of poorer quality used for stock feed have led to the name Horse Bean for this crop.

Some people are allergic to the pollen of the broad bean and also to the beans eaten in the green stage. An illness, sometimes fatal, known as "favism" is caused.

Aphids are the principal insect pest.

PEA.

(*Pisum sativum.*)

The pea is one of the oldest vegetables in point of cultivation, but it is not known just when the garden type of green pea originated. According to Sturtevant it was first mentioned distinctly about 1536. In the South it is commonly called the English pea. The crop should be brought to maturity under rather cool conditions, otherwise the yield will be light and the sugar in the peas pass quickly into hemicelluloses and starch with a consequent reduction in quality.

Fertilization.—A well-drained loam with a good sand content assists in obtaining earliness. The silt and clay loams are used for growing peas for processing. The method of fertilization depends upon the condition of the soil and the ultimate use of the crop.

It is well not to place the fertilizer in contact with the seed but to drill it in separately. Good placement is 1 to 2 inches directly below or a little to the side and somewhat deeper than the seed. Drilling the fertilizer in bands is better than broadcasting.

Market peas on sandy soils should be fertilized with a 1:1:1 ratio to supply 40 to 80 pounds of each of the three nutrients to the acre. In soils of a more loamy nature a 1:2:2, 1:3:2 or even a a 1:2:1 ratio is preferable to a 1:1:1. They should be used at a rate to furnish 30 to 60 pounds of nitrogen to the acre depending on the fertility of the land and whether manure has been used. Peas in the semi-arid sections of the West respond profitably to about 50 pounds each of nitrogen and phosphoric acid.

Usually peas for processing are grown in rotation with other farm crops so some of the residual fertilizer is relied on for the pea crop. Thus 60 to 80 opunds of phosphoric acid alone or with an equal quantity of potash is recommended in some of the mid- and northwestern states. Others suggest a 1:4:4 ratio at a rate to supply 10 or 15 pounds of nitrogen to an acre. In contrast to this the recommendations for the soils in the eastern states provide essentially

the ratios as used on the market crop with equal or even greater rates of application.

The soil should be no more acid than pH 5.5. Closer to pH 6.5 is desirable. Limestone can be applied down the drill spout along with the seed at the rate of 200 to 500 pounds an acre. This practice has been found to improve nodule development and nitrogen fixation on acid soils if the proper strain of legume bacteria is present.

FIG. 69.—The pods should be harvested when they are well filled, before the peas have become too hard and lost some of their sugar content. (Courtesy of Ferry-Morse Seed Company.)

The cost of inoculating the seed with nitrogen-fixing bacteria is relatively little but this practice has been found to increase vine growth and yield even on land which has grown peas previously and should contain the bacteria.

Propagation and Culture.—Early plantings will give greater yields than those made later. The soil may be plowed in the fall for real early seeding. Both the smooth and wrinkled peas may be planted as soon as the soil can be prepared. Early, mid-season and late varieties may be put in the ground about the same time, or successive plantings made of a good early variety, although the later plantings will yield less except in a cool summer.

It has been estimated in the East that each week's delay in the planting of peas for processing after early April will reduce the yield by 200 pounds of shelled peas to the acre.

The soil temperature should be at least 40° F. in the spring in the North before a planting is made. In the South and parts of the West, seeding is done from September to February depending on the mildness of the winter.

The home and market crop may be put in with a seed drill adjusting the depth according to the moisture content and degree of compactness of the soil. The cotyledons of the seed do not have to push up through the soil, so the depth may be 1 to 1½ inches or slightly deeper in dry light soil. The peas should be about an inch apart. Double rows 6 to 8 inches with 18 to 24 inches between pairs will permit a little early cultivation and the plants in the double rows will help support each other. Single rows are spaced 2 to 3 feet apart. Except for some of the late varieties which reach a height of 3 to 6 feet, no special support is needed. Brush, wire netting, or parallel lines of twine between posts will serve for these. The supports are placed along the center of the row. Between 60 and 100 pounds of seed per acre will be needed according to the spacing. The seed should be treated with 1½ to 2 ounces of Spergon, Arasan or Phygon per bushel to control rots in cold soil. If seed is treated with a disinfectant then the addition of nitrogen-fixing bacteria should be done just before the seed is placed in the drill.

Peas for processing are usually drilled in rows 7 inches apart. It is best for greatest yields to have about 16 plants per yard in the case of varieties with zigzag stems and 20 plants to the yard with the straight slender-stemmed varieties. This means that 20 and 25 seeds respectively should be dropped to the yard. The number of seeds to the pound of the different varieties is roughly from 1500 to 3000. Even two lots of seed of the same variety may differ, especially from year to year. The percentage germination of the lot must be considered also. All these factors influence the setting of the opening in the drill. Thus for the processing crop it may take from 12 to 20 pecks, 3 to 5 bushels, or 180 to 300 pounds of seed to plant an acre.

Irrigation is necessary in some pea-growing areas although the plants will root to about 4 feet in deep soil. Weeds can be controlled with special herbicidal sprays. Dinitro amine at 4 quarts in 30 to 50 gallons of water to the acre can be used as a preëmergence spray just before the peas appear above ground. Selective control of weeds is possible with a post-emergence spray when the peas are 4 to 8 inches high by the use of 2 quarts of dinitro amine in 60 to 80 gallons of water per acre. This rate is satisfactory

when temperatures are between 50° and 60° F. The quantity of dinitro amine must be reduced as the temperature rises. At 80° to 85° F., which is the upper limit for safe use, only 1 quart per acre should be applied.

Varieties.—The wrinkle-seeded varieties are sweeter than the smooth ones. Wilt-resistant strains have been developed in some of the older varieties, and there are many new varieties resistant to the wilts. Alaska is the only smooth-seeded variety in common use. Little Marvel, Progress, Thomas Laxton and Hundredfold are quick-maturing varieties of the wrinkled-seed type. Giant Stride and related strains are somewhat slower. Alderman is a high-quality pole pea. Mammoth Melting Sugar is one of the best edible-podded peas. It is prepared for use like a snap bean.

There are more than 100 varieties from which one might choose but those listed above continue to be the most popular. The shift has been merely to wilt-resistant strains. Some of these are used for both marketing and processing. It is well if varieties that are for processing bear their pods in pairs and are concentrated, that is, have most of the pods reach the harvest stage at the same time.

A dark-green color is required in peas for freezing but is not desired for canning. Wyola, Dark Skin Perfection and Dark Green Perfection are well adapted for freezing. Early Perfection and Wisconsin Perfection are the most popular varieties for canning.

Harvesting.—The pods should be plucked from the vine just as soon as they are well filled. Overmature peas are of poor quality. Deterioration proceeds rapidly at high temperatures. In the home garden the vines may be picked over several times. This will result in a higher quality product for the market gardener also, but is expensive, and the picking constitutes one of his greatest costs of production. Frozen peas have reduced greatly the market demand for fresh peas.

For processing the vines are cut at the stage when the best yield of prime quality peas will be secured. The vines are carried to a viner which beats the peas from the pods, or the two operations may be done by one machine as it travels through the field. The peas, after vining are rated for quality by means of a tenderometer. This instrument determines the pressure needed to force a definite volume of peas through a standard grid. The grading system is:

Grade	*Tenderometer reading*
Extra fancy	100 or less
Fancy	101 to 115
Extra standard	116 to 130
Standard	131 to 150
Substandard	More than 150

The price to the grower drops as the tenderometer reading rises. A reading of 90 to 95 will give about ¾ of the potential maximum yield of shelled peas per acre but the quality will be excellent. This tenderometer reading is the most desirable one for freezing. With adequate nitrogen the daily rise in the tenderometer reading at maturity may be slow but the yield increase rapid. Hot weather will cause a very quick rise in the tenderometer reading. It may increase as much as 15 to 30 units in a single day. Yields of shelled peas should be about a ton per acre, while for market the yield varies in different districts from 50 to over 150 bushels of pods per acre.

FIG. 70—Loading windrowed pea vines in the Northwest for transport to a stationary viner.

Peas should be cooled right after vining to prevent chemical changes which result in poor quality. They should be frozen or canned within a few hours. Similarly peas for fresh use should be kept iced until they reach the consumer.

Use of Heat Units.—Various methods are utilized in attempts to stagger the harvesting of peas for a processing plant so as to avoid overloading the facilities in any single day. The slope of the land; the type, fertility and drainage of the soil; the variety; and the temperature close to the plants all influence the date a crop will be ready for harvest. When peas are grown in an area year after year

at the same season it has been possible to develop a procedure for the orderly scheduling of plantings by predicting in advance the probable date a field of peas will reach a certain quality rating. Adjustments may have to be made in the prediction date during the growth period if abnormal weather occurs.

The heat unit accumulation system has been of practical value. The base, 40° F., is taken as the minimum at which any growth of peas will take place. This figure is subtracted from the daily mean temperature (68° — 40° = 28 heat units). These heat units or degree-days are accumulated as the season advances. An average of the degree-day accumulations for at least ten years for a given location is needed to establish the normal pattern. One must know also the total number of heat units usually required for a particular variety to reach the desired tenderometer reading in his area. For example in the principal pea growing areas this may range from about 1250 degree-days for the early varieties to 1700 with the late ones for a tenderometer reading of 100. Then one can predict for any given planting date the day in the future when the suitable number of heat units will have been accumulated. The seeding of the peas in the spring is separated by the number of days required at that time for the accumulation of the number of heat units that would result in just one day at the forecast harvest time. Thus planting dates for different growers' fields can be scheduled so as to give a fairly even flow of peas to the processing plant.

Insects and Diseases.—*Aphids* may be very destructive. *Pea weevil* injury is prevented by dusting the plants with a ¾ of 1 per cent rotenone dust just before the pods are set. Pea weevils can be controlled by use of 20 to 30 pounds of a 5 per cent DDT dust per acre applied just before the pods set and again seven to ten days later. If the rate is increased to 35 to 45 pounds to the acre pea aphids will be controlled also. Vines which have been treated with DDT should not be fed to cattle. More than 2 aphids to a plant can cause serious injury. While the treatments suggested above will help prevent misshapen pods, aphid control measures may need to be taken much earlier in growth. A 1 per cent TEEP, 1 per cent parathion or a 5 per cent malathion dust will be effective at 25 to 35 pounds per acre. These chemicals and DDT can be used in sprays at a rate to supply the equivalent quantity of actual materials to the acre. It takes 100 to 150 gallons of spray to cover adequately an acre by means of a ground rig but only 5 to 10 gallons by plane. Good control of aphids will reduce losses from *Mosaic*.

Thrips and *Leaf Miners* are injurious to pea plants in some areas. DDT, parathion, dieldrin and heptachlor will give control.

Root Rot is a cause of reduced yields. The stem is attacked just below the surface of the ground. This happens frequently just as the plants are coming into bloom. The plant may be a total loss or mature a few partly filled pods. Crop rotation, a well-drained soil and adequate fertilization will do much to control this disease.

Pea Blight is a disease similar in symptoms to the anthracnose of beans. It is one of the commonest and most widespread of the pea diseases. It attacks any part of the plant at any time during growth. Small, deep cankers appear on young pods. Those on the older pods are not deep but show the brown fruiting bodies in gray areas. After harvest the vines should be destroyed by deep plowing. Rotation combined with clean seed whenever this can be obtained will eliminate the disease.

Fusarium Wilt is caused by fungi which attack the base of the stems causing the plant to wilt and turn yellow. Wilt-resistant varieties should be used on infested land. *Near-wilt*, caused by a different race of Fusarium, will be avoided only by the planting of resistant varieties. New Era, a Perfection type pea, carries resistance to both wilt and near-wilt.

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Chapter 24

THE POTATO

THE white potato is the most important vegetable crop in the United States. During the five year period, 1949 to 1953, the average annual acreage was about 1½ million acres or only 54 per cent of what it had been a decade earlier. This decrease in acreage is offset by the rise in the average yield per acre from 133 bushels to 224 bushels for the same periods. This crop is called the Irish potato in the South, while the sweet potato is known by many people there as the potato.

WHITE POTATO.

(*Solanum tuberosum.*)

Although known often as the Irish potato in contrast to the sweet potato, this very important article of food came originally from South America, where it had been cultivated long before the advent of the Spaniards. The tuber is a swelling, arising at the end of an underground stem.

The climatic conditions are tremendously important in potato culture. A cool soil and air temperature during the growing season are necessary for proper tuber formation. Unless there is enough moisture through rainfall or irrigation to produce steady growth, the yield will suffer. If rains occur too close together toward the end of the growing season the spread of late blight will be increased. In the more northern states potatoes yield best if they come to maturity in the cool days of late summer. In the South the crop is grown in winter and early spring. This results in a succession of potato harvests beginning in Florida in early spring and moving on up the coast. In the West, California leads in the production of early potatoes. The crop for fall harvest and storage is grown primarily in the northern tier of states where daily average temperatures in the summer will be between 65° and 75° F.

Fertilization.—A well-drained loamy soil is best for potatoes. The real light or the very heavy soils will not produce the highest yields. Muck soils are being increasingly utilized for potato production. Quality, brightness of skin and shape are best on the more friable soils. A high content of organic matter should be built up by the rotation. A good alfalfa sod, clover sod or a green

manure should be turned under in the fall for the potatoes. Manure may be used on some other crop in the rotation or as a top dressing after the first cutting of hay. Thorough harrowing will help control weeds before the seed pieces are planted.

The potato will make profitable use of rather heavy applications of commercial fertilizer. The amount may be increased as long as the returns justify the expense.

The early season crop that would be produced on sandy or sandy loam soils could use a ratio approaching 1:1:1 and supplying 100 to 140 pounds of each of the three nutrients to the acre if planted on land well-fertilized previously. Otherwise a 1:2:2 ratio at a rate giving about the same quantity of nitrogen should be applied.

Main-crop potatoes are grown on heavier soils than is the early crop. In the East these late potatoes should be fertilized with an analysis having a ratio of 1:1:1 or one slightly higher in both phosphoric acid and potash if the crop is part of a well-fertilized rotation, or has had a good legume sod or 10 tons of manure turned under ahead of planting. These ratios should be used at a rate that will supply about 100 to 120 pounds of nitrogen to the acre. Without this past history of fertility improvement a 1:2:3 ratio or one somewhat lower in potash is preferred. The rate of application should provide 120 to 150 pounds of nitrogen an acre. The Northwest uses a 1:2:2 ratio giving about 75 pounds of nitrogen to the acre. In the Middle West a 1:4:4 ratio is recommended at a rate to supply 30 to 40 pounds of nitrogen per acre. Potatoes on some soils in that area receive 100 pounds of phosphoric acid alone per acre. In the semi-arid sections of the West an application of 100 to 150 pounds each of nitrogen and phosphoric acid is justified.

The fertilizer recommendations for potatoes on peat or muck soils in the East are a 1:2:1 ratio on newly-cleared land and a 1:2:2 on soil that has long been in use. In both cases the rate of application supplies about 100 pounds of nitrogen an acre. On the other hand in the Northwest muck soils are fertilized with a ratio of about 1:3:3 providing 40 pounds of nitrogen to the acre, while in the Middle West 1:3:6 or 1:3:9 ratios supplying 20 to 45 pounds of nitrogen per acre are favored. Potatoes on California peat soils should be fertilized with a 1:1:1 ratio to give 150 pounds of each of the three nutrients to the acre.

Some of the soils in the East that are more acid than pH 5.5 are low in magnesium. Fertilizers used on potatoes can be compounded to include enough of a soluble magnesium salt to furnish 30 to 50 pounds of magnesium oxide to the acre.

In Florida if manganese deficiency appears in potatoes on certain soils it can be corrected with a foliage spray containing 1½ to 2 pounds of manganese sulphate in 100 gallons of water.

The fertilizer is usually applied at planting time by an attachment on the planter which places the chemicals in bands 2 inches to the side of the seed pieces and at the same level or slightly deeper. When more than 1,000 pounds of fertilizer is to be used to the acre, it is best to broadcast and harrow in half of it before planting, and then put the remainder in bands, because too heavy an application in bands may cause burning of the sprouts. Even with 1,000 pounds per acre, care must be taken that the fertilizer does not come directly in contact with the seed pieces.

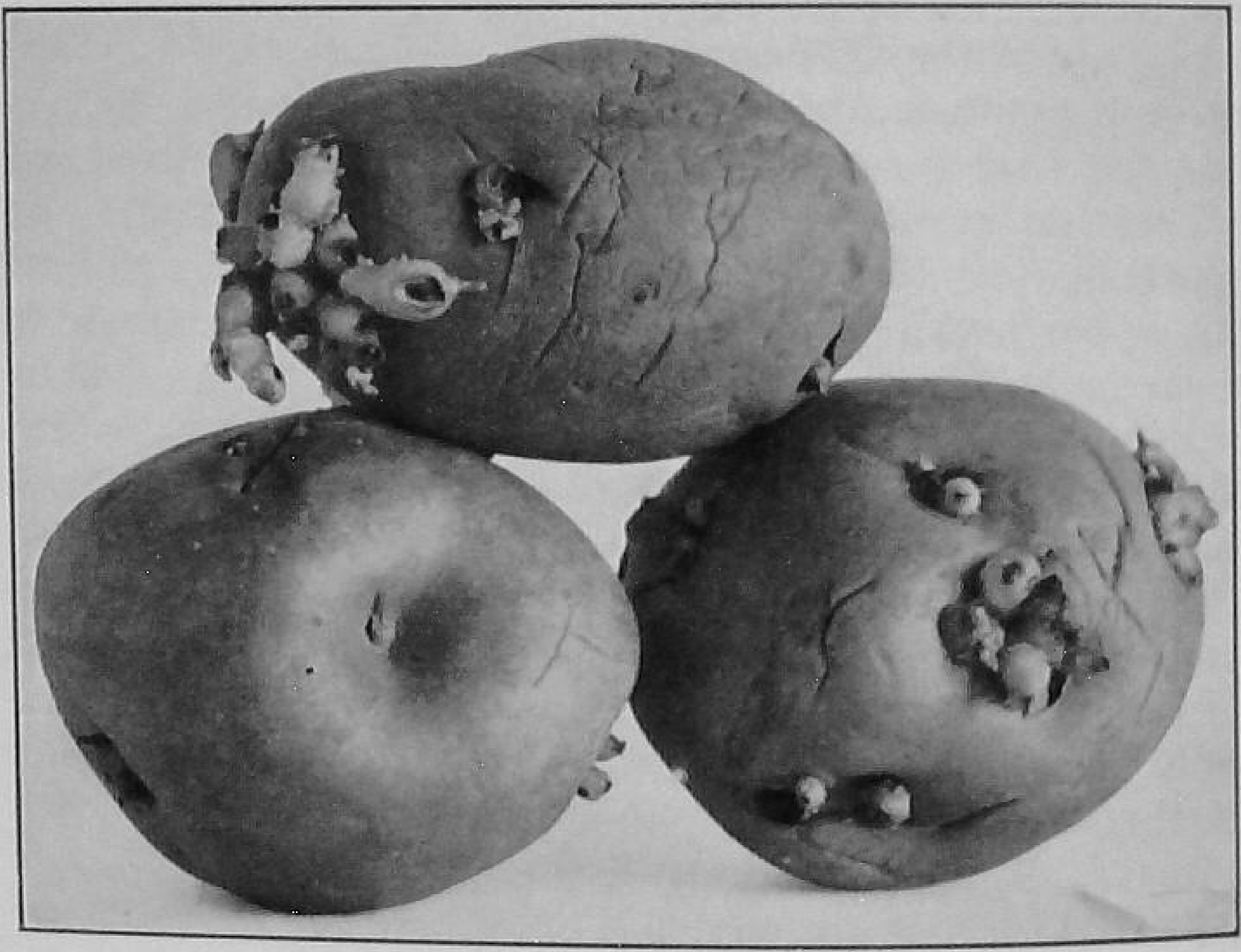

Fig. 71.—The dominant eyes at the apical end of a potato sprout first, but when the tuber is cut the others will develop. (Boyle.)

Liming the soil for potatoes is not desirable unless the soil reaction is more acid than pH 4.8. Good yields of potatoes free from scab can be obtained when the soil reaction is between pH 4.8 and 5.4.

Propagation and Culture.—Early potatoes may be planted just before the last killing frost. The sprouts will develop at a low temperature although they may be injured if they appear above ground and are subjected to a killing frost. It is safe usually to plant by the time it is possible to get the seed bed thoroughly prepared. By this time the soil temperature at planting depth will be about 45° F. The crop for fall harvest is planted at such a time that it will make about one hundred and twenty days growth before the first killing frost. In areas with a short season, planting of late potatoes must take place as soon as the soil can be prepared in late spring.

Good seed potatoes are an important factor in determining yield. Slightly immature, disease-free seed is preferred. Certified seed is from carefully inspected fields and has been checked over after digging to ascertain whether it meets the standards. When certified seed can be obtained, its higher cost is justified.

The seed piece should be large enough to provide food for the development of at least one sturdy stalk. A chunky piece 1½ to 1¾ ounces in weight is satisfactory and will dry out less readily than a thin piece. The quantity of seed to an acre depends upon the spacing, but should be from 20 to 30 bushels or more. If the cut seed must be held several days before planting it should be kept at 60° to 65° F. with a relative humidity of 85 to 90 per cent to facilitate healing of the cut surfaces. Small whole potatoes known as single-drop seed are used by some growers. Where plantings are made during hot weather for a late fall crop, the seed pieces should be planted as soon after cutting as possible and meanwhile kept moist and protected from the sun and drying winds.

Most potatoes are planted by machine. The type in most general use is the picker in which points jab into the seed pieces and then drop them at the proper intervals. It is fully automatic but may spread certain diseases. The assisted-feed planter which has pockets on a horizontal plate requires that a man for each row ride the machine to see that each pocket has a seed piece, but not more than one. This type usually allows fewer skips than the picker type. Hand dropping of the seed pieces is confined to small scale plantings.

The high yields reported in recent years have been obtained partly by reducing the distance between rows and seed pieces. Smaller size of seed piece is employed in close planting. A distance of 30 to 36 inches is allowed between rows, with the pieces spaced 12 to 14 inches or even less. In plantings made with close spacing of the seed pieces in the row, the tubers are likely to be more uniform in size and not so large as at wider spacings. This is important with varieties like Kennebec and Katahdin that tend to set but a few tubers. Some of the new varieties have so few eyes that even 2 ounce seed pieces must be used with close spacing.

The seed pieces should be planted 3 to 5 inches below the level of the soil surface. The early crop started in cold soil is planted shallower than the late crop. Heavy soils call for shallower planting than light soils. In soils where Rhizoctonia is severe, shallow planting of the seed pieces enables the shoots to get to the surface with a minimum of damage. Most of the tuber-producing stolons arise from the stem above the seed piece. Thus the tubers are found between the seed piece and the surface.

Cultivation.—Weeds must be controlled. A broad sweep weeder may be drawn over the rows until the plants are 8 to 10 inches high. Each succeeding row cultivation should be even more shallow and further from the plant than the previous one. When root injury cannot be avoided cultivation should cease. In the process of cultivation the soil is thrown sometimes onto the row and ridges developed which provide easier digging, better weed control and easier handling of excess moisture. Too much of a ridge may reduce the yield in a dry season. Even in the level culture system some soil is thrown to the row toward the end of the season to protect the developing tubers from sunburn and greening.

Where grasses are not prevalent good weed control with only one late cultivation for hilling purposes has been obtained by chemical methods. Just before the potato plants emerge the area can be sprayed with one of the dinitro compounds. Experiment stations should be consulted as to the latest recommendations on rates and materials.

Chemical weed control has another advantage in that it reduces the number of times equipment has to travel through a field. Thus the soil is not compacted so much. Potato soils should have about 49 per cent of their volume as pore or air space. This is one of the most critical factors affecting potato yields. Every trip through a field that is made by a piece of equipment, especially when the soil is moist, compacts the root zone and reduces the pore space.

Irrigation.—Many acres of potatoes are grown under conditions where the moisture supply is dependent entirely on rainfall. On the other hand with closer planting of seed pieces and increased application of fertilizer, growers have found it profitable for the early crop to use sprinkler irrigation. In the western states, most of the potatoes are grown with furrow irrigation.

Ridges thrown over the rows between the furrows should be fairly wide so as to give room for the development of the tubers and their protection from the sun.

Alternate wet and dry soil conditions, after the tubers have started to grow cause second-growth which is characterized by knobby or multiple potatoes. A constant moisture supply is therefore important for continuous growth and the production of smooth potatoes.

Potatoes are a shallow-rooted crop. The irrigation practice should be such as to keep available moisture in the top 2 feet of soil. This may call for from 4 to 10 or more applications of water depending on the soil type, humidity and prevailing temperatures. At each irrigation 2- to 4 acre-inches of water should be applied.

Varieties.—As with other vegetables, the potato variety situation is changing constantly. Many of the older varieties which have

been used for many years have been replaced by new ones resulting from a wide-spread national potato-breeding program. The quicker-maturing varieties are used for spring and late fall harvest where conditions permit. While the new varieties have some resistance to certain diseases, they are not equally well adapted to all potato-growing districts of the country. Much still needs to be learned regarding this aspect of their use. There is great need for varieties resistant to the different races of scab.

Quick maturing.—The Irish Cobbler and Bliss Triumph, which has reddish skin, are the most important varieties in this group. In California the White Rose is used extensively for the early crop. New quick-growing varieties are Earlaine with resistance to mild mosaic and aphid transmission of virus A; Mesaba; and Warba, which is resistant to mild mosaic and yellow dwarf.

Medium maturing.—The days to maturity for these varieties are intermediate between the other two groups. Chippewa is resistant to mild mosaic, virus Y and net necrosis. Houma resists mild mosaic, yellow dwarf and net necrosis. Kasota is somewhat resistant to fusarium. Mohawk is resistant to mild mosaic. Cherokee is very resistant to some races of scab and late blight.

Slow maturing.—These varieties are used for the main or late crop for storage. Russet Burbank or Netted Gem, Russet Rural, Green Mountain, and Rural New Yorker No. 2 are old varieties which are still popular. Pontiac is resistant to yellow dwarf. It has red tubers. Katahdin is reported to be resistant to mild mosaic, yellow dwarf, net necrosis, virus Y and aphid transmission of virus A. Sebago has resistance to late blight, mild mosaic, yellow dwarf, net necrosis and somewhat to brown rot in the South. Sequoia resists late blight, flea beetles, and leaf hoppers. Kennebec has great resistance to late blight, net necrosis and mild mosaic.

Harvesting and Storage.—Potatoes are harvested from the time they are of sufficient size until the vines have fully ripened, depending upon whether the crop is destined for the early market or for late sale and storage. Where early harvesting puts the crop on a higher-priced market, the greater yield which could have been obtained by full maturity may be worth sacrificing. On the other hand, immature potatoes shrink severely, bruise easily and will not keep well.

The tubers are dug more easily if the vines are destroyed first with a mechanical beater. Special care must be exercised if chemicals are used as vine killers. Potatoes are usually lifted to the surface with one- or two-row diggers pulled by a team or tractor. The tubers are picked up and placed in containers by hand. Combines that dig and load in one operation work well on soil free of stones and clods. Excessive bruising occurs readily in many steps of the

harvesting and handling operations. This injury can seriously lower the yield of U. S. No. 1 potatoes. From 100 to 400 bushels an acre are the usual yields although larger ones are obtained in favorable areas.

Potatoes harvested immature for the early market are very perishable. They skin readily with subsequent development of an unsightly brown discoloration of the exposed surface. They should be picked up as soon as dug especially if the weather is warm, dry and windy. Tightly woven picking sacks and the use of covers over the truck loads while enroute to the packing sheds are helpful in reducing injury from drying. Such early tubers should be

FIG. 72—A mechanical potato harvester in operation in the Red River Valley. (Courtesy U. S. Department of Agriculture.)

treated gently in all digging and handling operations as well as being protected during shipment.

Washing of early potatoes is a fairly common practice. It does tend to increase the amount of skinning and may spread rot organisms. Sometimes the tubers are dried after washing. Delaying the digging until the skins are mature is the simplest way of avoiding all these difficulties.

Newly dug potatoes must be handled with great care until the surface has dried or cured for a few hours. They may be placed in slatted bushel crates and kept in these until used. The potatoes should be graded before they are sold. All those should be discarded which are not well shaped, free from disease or other injury and of proper size for the grade. Sound mature tubers should be

stored in darkness under conditions of a 90 to 95 per cent humidity and a temperature of 36° to 40° F. or at 50 to 60° F. if they are to be used in a couple of months. It is well to reduce the temperature of the potatoes designed for long storage gradually so that they will not reach 40° F. until they have been in storage about two weeks. The amount of starch changed to sugars in the tubers increases as the temperature of the storage is lowered. Both reducing sugar (mostly glucose) and sucrose are formed. The reducing sugar if present in any great quantity will cause an undesirable dark brown color in potato chips and French fries. The reaction is reversible so the sugar will disappear if potatoes which have been subjected to low temperatures are held for several weeks at 70° F. before use. The cooking quality of potatoes is best if the sugar content is at a minimum.

Potatoes pass through a rest period of 8 to 15 weeks, varying with varieties, during which they will not sprout even if the temperature and humidity are favorable. In order to hold the tubers to be used for food in a dormant condition at 40° F. or above after the rest period is over, they can be treated with the methyl ester of alpha napthalene acetic acid at the rate of about 1 ounce to 30 bushels of potatoes. It can be sprayed or dusted on the tubers as they are put in bins, or else shredded paper impregnated with the chemical can be distributed through the pile. Another way is to spray the vines four to six weeks before harvest with MH-40, a formulation of Maleic Hydrazide. With both of these methods the manufacturer's directions should be followed.

Even though a potato does not show any external effect from an exposure to a freezing temperature darkened tissue will be found if the potato is cut and the flesh exposed to the air. Another storage trouble, is *blackheart*, resulting from an insufficient supply of oxygen. When potatoes are placed too deep in piles or bins blackheart may develop.

Handling of Seed Potatoes.–Potatoes which are to be used for seed should be stored at about 38° F. until a few weeks before planting when their temperature should be raised to 50° F. This will result in a quick come-up and uniform stand after the seed pieces are planted.

In some sections of the country plantings are made so soon after the seed potatoes have been dug that there is insufficient time for the tubers to pass through their rest period. The rest can be broken by barely covering the freshly-cut seed pieces with a 1½ per cent solution of sodium or potassium thiocyanate in water. After the one and a half hours soaking the seed pieces should be planted promptly. Great care must be exercised in the use of these chemicals as they are very poisonous.

Insects and Diseases.—The *Colorado Potato Beetle*, the *Potato Psyllid*, *Flea Beetles*, and *Leaf Hoppers* are serious insect pests of this crop. They can be readily controlled with 2 to 4 pounds of 50 per cent wettable DDT in 100 gallons of water or with a 3 to 5 per cent DDT sulfur-talc dust. *Aphids* are troublesome sometimes. Their control involves the use of nicotine, pyrethrum, rotenone or one of the new aphicides. DDT is not too effective on aphids. See Chapter 13 for the control of *White Grubs*, *Millipedes* and *Wireworms*.

There are many diseases of the potato. *Leaf Roll*, *Yellow Dwarf*, *Spindle Tuber* and *Mosaic*, which are well described by their names are virus diseases. It is this type of disease that is mainly responsible for the degeneration or running out of seed potatoes. They are known to be spread from plant to plant in the field by insects and passed on to the next crop through the tubers. Seed potatoes from disease-free fields and insect control constitute the method of prevention. Varieties have already been mentioned that have resistance to some of these and to other diseases.

Early and *Late Blight* are fungous diseases of the foliage which necessitate the protection of the leaves with a Bordeaux film from the time the plants are up until they mature or are killed by frost. The number of times that the treatment must be applied depends upon the weather and rate of growth. Early blight is carried over in the soil on plant refuse, so rotation helps. The late blight fungus overwinters in the tubers. Healthy seed is desirable. Late blight lesions on the tubers may permit access of other rot organisms, with consequent increased storage losses. While Bordeaux spray or copper-lime dust have long been the standard control for these diseases, the fixed or insoluble copper compounds and certain of the dithiocarbamates are now recommended by some Experiment Stations.

Fusarium Wilt is caused by a fungus which can remain in the soil for considerable periods. An affected plant wilts, turns yellow and dies. When plenty of humus is present in the soil this disease is rarely destructive. Long rotation and use of seed from disease-free fields are the control measures recommended.

A blackening and rotting of the stem with resultant stunting and death of the plant is known as *Blackleg*. The bacilli may be carried over on the tubers. Seed from disease-free fields and discarding infected tubers will help in control.

Ring Rot is another bacterial disease. It appears to be disseminated only in the handling, seed-cutting and planting operations. Disease-free seed is the logical control.

Scab and *Rhizoctonia* can sometimes be controlled by rotation and seed treatment. The best control for scab is a soil reaction of pH 5.0 to 5.4. Scab shows as corky areas and rhizoctonia as raised black specks or scurf on the tubers. The latter disease is present

also as brown lesions on the stems below ground, or may result in death of sprouts before they get above ground, and in the production of aërial tubers. It is less serious under the high temperatures of the South. Seed potatoes should be treated before cutting even though they are certified. Soaking for one and a half hours in a solution of bichloride of mercury (corrosive sublimate), 4 ounces in 30 gallons of water, is effective in the control of rhizoctonia. Wooden vessels should be used. Not more than 3 lots should be placed in the same solution. After treatment the potatoes should be laid out to dry. If the solution is heated to 124° to 126° F., the time of immersion is cut to two and one-half to four minutes. Seed potatoes can be dipped for a moment in a suspension of 1 pound of yellow oxide of mercury in 30 gallons of water and then dried. Where scab is a factor, the mercury treatments should not be used. Cold formaldehyde is not too effective in the control of rhizoctonia but the hot method is good for both diseases. Two pints of commerical formaldehyde are added to 30 gallons of water. The temperature and period of immersion are the same as with the hot bichloride solution. The acid-mercury solution is prepared by dissolving in a wooden vessel 6 ounces of bichloride of mercury in 1 quart of hydrochloric acid. This solution is then added to 25 gallons of water in a wooden barrel. The potatoes are soaked for five minutes and then dried immediately. The 25 gallons will treat 30 bushels or more unless the tubers are very dirty.

The mercury compounds are very poisonous, and the acid and formaldehyde caustic or irritating. They should be handled with great caution and disposed of carefully after use.

There is no uniformity in the recommendations of the various Experiment Stations with regard to potato seed treatment. In general it may be said that treatment gives satisfactory results only when the seed is to be planted in soil which is relatively free from the scab and rhizoctonia organisms.

Improvement of Stocks.—The elimination of virus and other seed-borne diseases and the selection of high-yielding strains are the basis of the improvement program. Very productive hills of potatoes which are free from disease are selected in the field by the seed grower. One good tuber is saved from each hill. The next year and in succeeding years the plantings are made by the *tuber-unit* method whereby each tuber is usually quartered into four seed pieces which are planted in succession in the row. A hill is skipped between the units from different tubers. This method helps eliminate the seed-borne diseases since if any plant shows disease then all the plants from that tuber are easily located and destroyed. *Tuber-indexing* is exclusively for locating disease. It involves the

preliminary planting usually in a greenhouse or frame of a small one-eye piece cut from each tuber. Each tuber and its cut-off eye bear the same number so that the tuber can be discarded if the eye shows disease in the early planting. Sometimes these eye indexes are sent to southern areas where they can be planted in the open during the winter months.

The original selection for yielding ability sets the level of productivity since future selection and testing cannot change the yielding ability of any of these strains arising from a single tuber but can only eliminate the poorer ones. Eventually by checking performance in yearly tuber-unit plantings as the stocks are increased, the seed grower ends up with several good strains or tuber lines which constitute improved stocks or foundation seed.

Certification.—If he wants his stocks certified he rogues his fields carefully for diseased plants and arranges with State officials who make usually two field inspections and one post-harvest check-up for varietal purity and for the presence of diseases which could be seed-borne. The procedures and requirements differ somewhat in various states. Crops which meet the established standards are tagged as "certified seed potatoes."

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Chapter 25

MISCELLANEOUS COOL-SEASON CROPS

THERE are a number of vegetable crops which are of considerable importance in certain sections of the country. A few of these are discussed in this chapter. They do not fit well in any of the groupings which have been used in presenting the material concerning the other crops.

CARDOON.

(Cynara carduncculus.)

This crop is closely related to the globe artichoke, the foliage of the two being quite similar. It is grown for its edible petioles as is celery. A large-sized plant with a leaf length of 3 to 4 feet and diameter at the base of 3 to 6 inches may be formed in a favorable season on very fertile soil. The plants without spines on the petioles are more desirable. Spiny and spineless varieties are offered by foreign seedsmen.

A good rich loam well fertilized plus occasional side dressings with liquid manure or soluble nitrogen will produce a good growth. Seed may be started under glass and transplanted to the field where a short season prevails. The most common method in the San Francisco Bay counties is to start the seed in an outdoor plant bed in May or June. As soon as they are large enough the plants are set in the field. A spacing of 12 to 18 inches in rows 4 feet apart is usual. Clean culture should be given during growth.

A month or more is needed to blanch the stalks. The leaves may be drawn together and heavy paper or burlap wrapped rather tightly about the clump of petioles. These materials are likely to be more satisfactory than attempting to cover the plant with straw and soil or soil alone.

The blanched plants are cut off just below the crown, the outside petoiles trimmed off, as well as the leafy parts. There will remain a blanched heart some 18 to 24 inches in length by 2 to 3 inches in diameter. The petioles of this heart are cut into sections which require parboiling for an hour and a half before they are tender.

Cardoon keeps fairly well for a few weeks in a dark cool place even without refrigeration. Unless freezing weather develops the mature plants may remain in the garden for eight to ten weeks

with little deterioration. The greatest market demand is at Thanksgiving and Christmas.

GIRASOLE OR JERUSALEM ARTICHOKE.

(Helianthus tuberosus.)

The North American Indians knew and cultivated this crop for many years. It is not an artichoke and the name Jerusalem is supposed to be a corruption of the word Girasole.

The Jerusalem artichoke will survive as a perennial arising each year from any tubers left in the ground. It is grown as an annual, but unless the volunteer plants are eradicated early the next year, it may become a persistent weed.

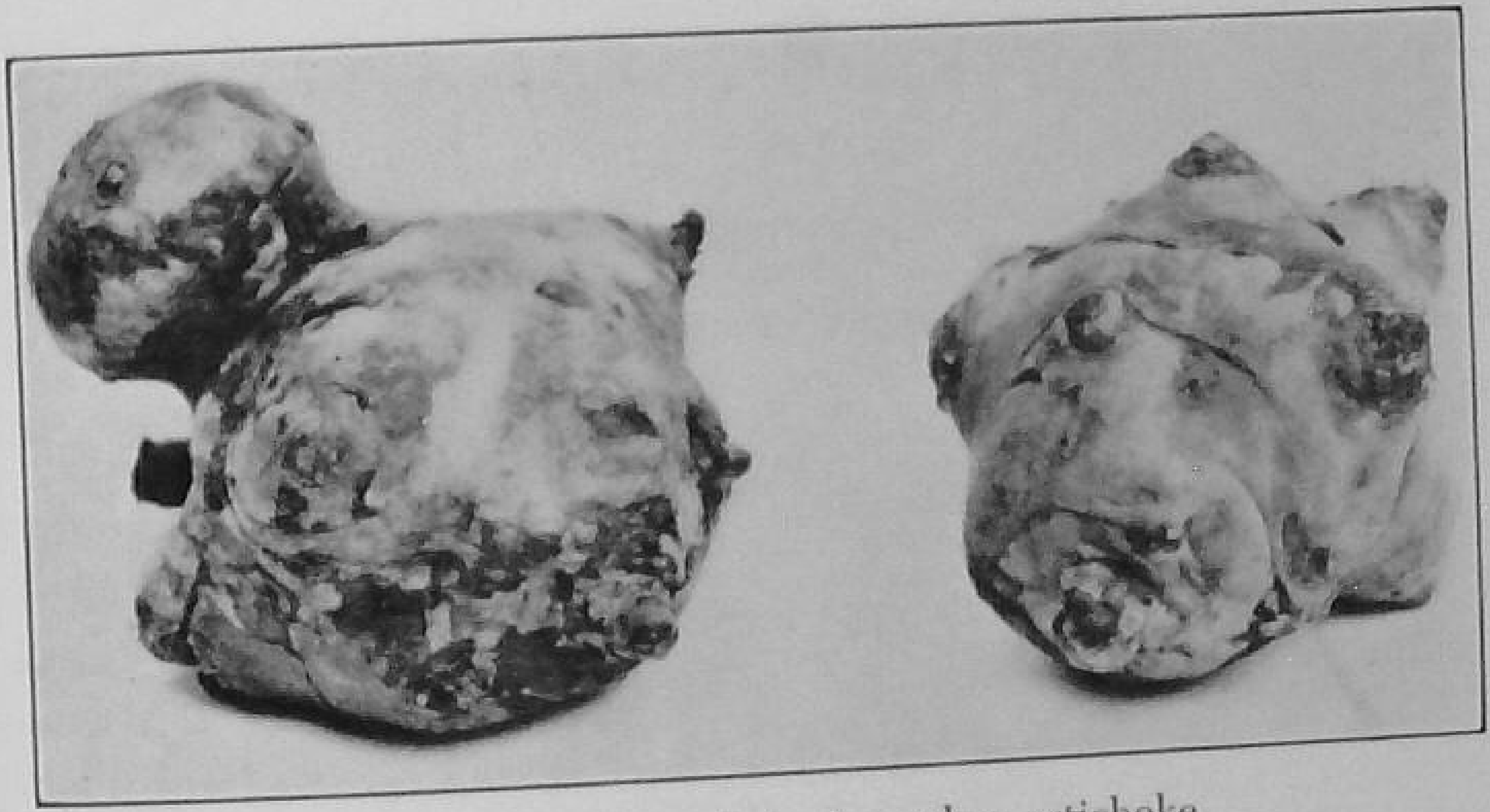

FIG. 73.—Tubers of the Jerusalem artichoke.

The edible part of this member of the sunflower family is the tuber or swollen end of an underground runner, which in some respects resembles a potato, and may be used similarly. Considerable of the stored carbohydrates in the case of Jerusalem artichoke is inulin. It appears to be a promising source for the commercial production of levulose sugar, which has dietary use in the treatment of diabetes. Yields will vary between 5 and 10 tons an acre.

The preferred seed piece is an entire 2-ounce tuber but larger ones may be divided into pieces that size. These are planted usually 4 inches deep during very early spring at 18- to 24-inch intervals in rows 3 to 4 feet apart. Under very favorable conditions wider spacings than these are possible. Whole tubers should be used if fall plantings are made.

The use of commercial fertilizer besides manure will be profitable on soils that are not high in fertility.

The varieties are mostly wild types and there is a good opportunity for improvement work in the development of better types. According to Shoemaker, the characters to be sought are greater yield, increased inulin content, earlier maturity, and more compact development of the tubers about the base of the stem. Only those stocks should be planted that are known to be high yielding and of acceptable quality.

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Part III. Warm Season Crops

Chapter 26

THE SWEET POTATO

THE acreage planted to sweet potatoes annually in the United States has been dropping steadily for some years. From 1949 to 1953 the average annual harvested acreage of sweet potatoes was only 390,800 acres. In addition to fresh consumption, sweet potatoes are used as cattle feed and as a source of starch.

SWEET POTATO.

(Ipomoea batatas.)

The cultivation of this native of Tropical America was probably known to the inhabitants of the New World long before the arrival of Columbus. The sweet potato requires a warm growing season which must be close to four months in length between frosts for even the early varieties. This fact coupled with its tenderness renders its culture difficult in the North. Although the plants will stand considerable dry weather, a moderate amount of rainfall or supplementary irrigation is desirable. The edible portion consists of a very much thickened root. Too much water tends to make the roots more elongated and less blocky.

Fertilization.—Well-drained, sandy loam soils produce a better quality root than heavy soils, which may give rise to too much vine growth or poorly shaped roots. A very rich soil is not desirable for the same reason. The soil should be well-prepared to a depth of 6 or 7 inches. Too deep a soil is thought to result in long slender roots. Manure is not desirable for this crop although it may be used to advantage elsewhere in the rotation. Liming is not necessary except possibly in very acid soils low in fertility.

It is impossible to generalize on what should be the proper fertilizer program for sweet potatoes. When they are planted in soils markedly deficient in potash the application of heavy quantities of potash have given some indications of making the sweet potato roots more chunky. The recommendations in most states call for the use of analyses which are of about a 1:2:1, 1:3:1 or

1:2:2 ratio. Such analyses are applied at a rate which will supply 25 to 50 pounds of nitrogen depending on the fertility of the soil.

The fertilizer should be put in bands about 3 inches from each side of the row. This can be done as the ridge is thrown up or by putting a fertilizer attachment on the transplanter. Work in New Jersey suggests that it is beneficial to use a starter solution in the water at transplanting and to apply all the fertilizer in solution

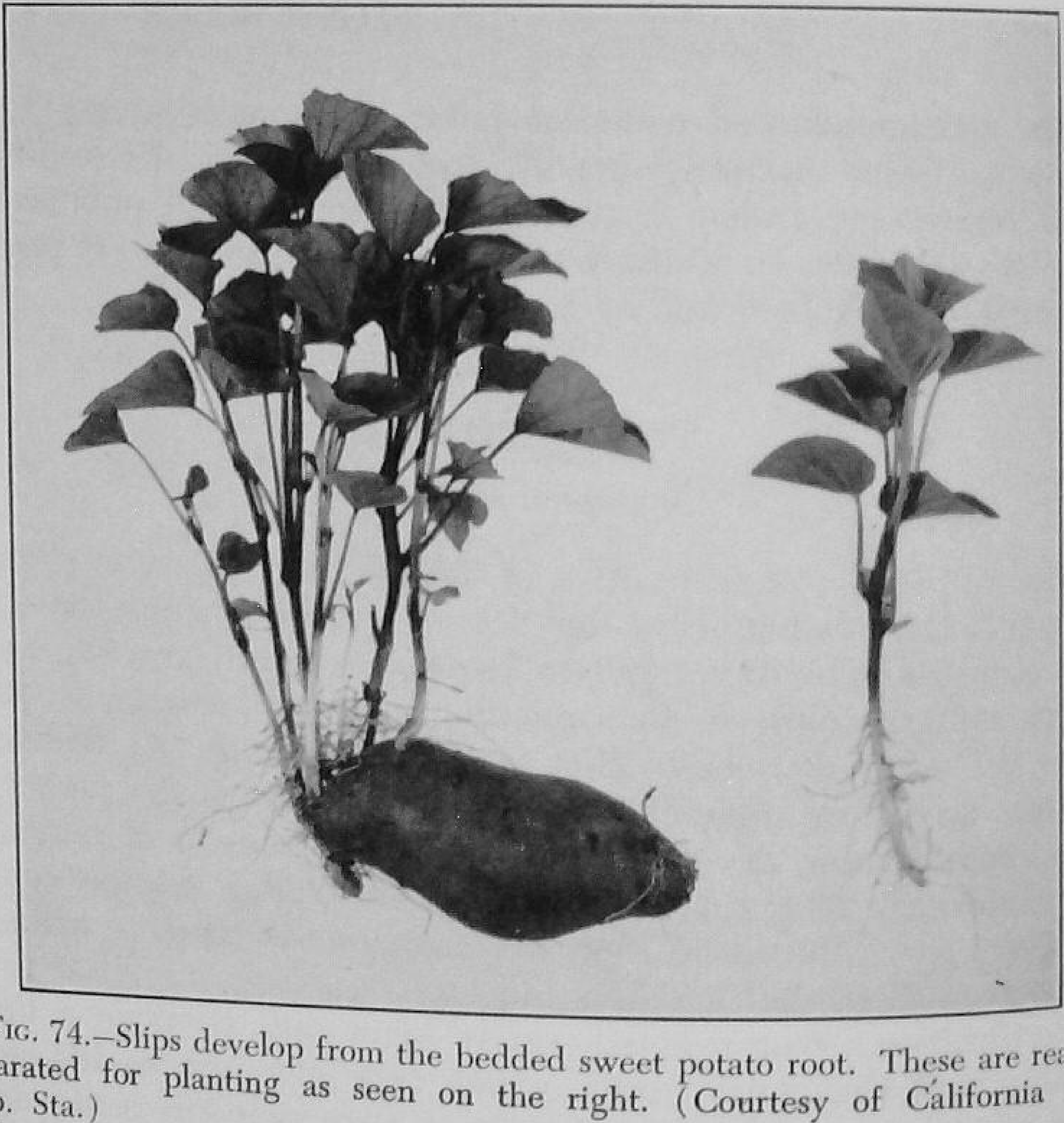

FIG. 74.—Slips develop from the bedded sweet potato root. These are readily separated for planting as seen on the right. (Courtesy of California Agr. Exp. Sta.)

along the row about two and six weeks after planting, especially in dry weather. The sweet potato root system is sensitive to a concentration of fertilizer salts so injury could occur if heavy applications of dry fertilizer are made in the ridge and rainfall is lacking.

Propagation and Culture.—There is considerable difference of opinion concerning the desirability of planting on a ridge or on the level. Ridges aid in draining away excess moisture, but in a dry season may reduce the plant growth if they are too high. A

ridge height of about 12 inches is usually adequate. The ridges should be made about a week ahead of planting so that they will settle. The tops are rolled or leveled just before planting. The centers of the ridges are commonly about 3½ feet apart, although they may be from 2½ to more than 4½ feet apart depending on the fertility of the soil. Rich soil will support close spacing.

The best method of propagation is by means of sprouts arising from medium-sized roots, 1½ inches in diameter, that are bedded in heated or unheated plantbeds. These plants are sometimes called draws or slips. A bushel of roots will occupy 12 to 15 square feet of bed. This quantity of roots will produce about 1000 plants at the first pulling, and perhaps a total of 1500 to 2000 if several pullings are made at weekly intervals. It is wise to bed 10 to 12 bushels of roots for each acre of field to be planted so there will be no great delay in getting the transplanting done once weather conditions are suitable. Any delay means a reduced yield.

Proper selection of clean seed is of great importance in the control of stem rot, black rot and foot rot. The hills free from stem rot can be selected in the fall at digging by splitting the stems of the vines to see that the inside is not discolored. There is need for more wide-spread certification of sweet potato seed stocks. The roots must be treated before bedding to control surface-borne diseases. Soaking for ten minutes in a solution of 6 pounds of borax in 30 gallons of water with immediate planting without rinsing is a simple effective method. The borax is dissolved in some hot water first and then the solution made up to the 30 gallons with cold water. A one-minute dip in a Semesan Bel solution or an eight-minute soak in a 1 to 1000 solution of bichloride of mercury are other methods of treatment.

An open plant bed or one covered with sash is used. The roots are placed on a 3- or 4-inch layer of sand or sandy loam which has never grown sweet potatoes. The seed potatoes should not touch one another. They can be covered with medium mesh chicken wire to prevent the lifting of the roots from the soil when the plants are pulled. About 2 inches of clean sand is placed over the bedded roots. The plantbed must be kept moist but not overwatered as this might chill the roots.

Temperature control is important. The air temperature should not rise above 85° F. It is best if the soil temperature is 75° to 80° F. when the roots are bedded. The soil should then be kept close to 80° F. at first and reduced to 75° F. later. Growth of the sprouts almost stops at 60° F. Heating of beds with manure, steam, electricity, hot water or hot air flues is desirable to get these temperature conditions. In four to six weeks the first sprouts will be 4 to 5 inches tall and ready for pulling.

Early planting of the slips as soon as frost danger is past will do much to increase the yield. Early plantings have been shown to produce chunkier sweet potatoes than do late plantings. The importance of early planting in the spring tends to emphasize the desirability of using hot beds for the production of slips rather than coldframes or open plant beds.

A pull will sever the slip from the parent root which is held down with the other hand. A good number of roots will be formed already on the stem of the little plant. If water is withheld and the night temperature reduced for a few days before pulling the plants will be hardened and stand the transplanting better. Transplanting machines which apply water at the roots are useful. When the slips are put in by hand using wooden tongs or other tools, and the soil is dry, water should be applied or the roots "puddled" as pulled by dipping them in a thin mud batter. Puddled roots must not be allowed to dry out before being set in the ground.

Vine cuttings 10 to 12 inches long are taken in the field from the plants which were set out first, although if this practice is excessive the yield of the vines is reduced. These are pressed into the ground until just the tips stick out and then are carefully firmed.

As the space between plants in the row is increased from 8 or 12 inches to 24 inches or more, there is usually some reduction in total yield and the yield of No. 1 roots but an increase in the oversized roots. Thus close planting is desirable.

Weed control is a difficult problem. Many growers prefer to use land for sweet potatoes which is well rid of weeds. Cultivation is given as often as necessary until the vines cover the area. Disturbing them after this seems to reduce the yield. Some hand pulling of large weeds may be necessary among the vines as they may interfere later with harvesting.

The sweet potato is a deep-rooted plant. Sandy soils, which are preferred for this crop, are likely to contain little available water. In humid areas rains usually replenish the supply of soil moisture, but in arid regions it is necessary to supply as much as 18 inches of water per acre by irrigation.

Pruning of the tips of the vines reduces rather than increases the development of the potatoes.

Varieties.—Thompson and Beattie have classified the varieties into 8 major groups, each named for the most widely known or typical variety. These groups are the Ticotea, Belmont, Pumpkin, Spanish, Shanghai, Florida, Southern Queen and Jersey.

The Yellow Jersey and Big-stem Jersey are dry-fleshed varieties of the Jersey group. They have been very popular on northern markets. The moist-fleshed varieties are often called "yams" but

the true yam is an entirely different plant. Of the moist-fleshed varieties the Puerto Rico of the Spanish group is the most popular. The moist-fleshed varieties are demanded on the markets of the South and are coming into more general use by consumers in the North. There are a number of strains of the Puerto Rico and others of similar type, some of which are particularly good yielders. Nancy Hall, with moist flesh and Triumph with medium moist flesh, are also used.

Breeding programs are producing new varieties such as Allgold, Redgold, and Goldrush with some resistance to stem rot and other diseases. Nemagold is resistant to nematodes.

Harvesting and Storing.—Sweet potatoes may be dug as soon as they reach marketable size if destined for immediate sale. The crop for storage should be allowed to grow as late in the fall as possible because the yield will increase. However, it is important that the potatoes be prevented from becoming chilled from low soil temperatures. They should be dug before the first killing frost. There is no need of cutting the vines if a sudden frost kills them. The emphasis should be on getting the potatoes out of the ground as quickly as possible.

The first step in harvesting is to cut the vines and move them between the rows. This is done by hand, by special vine cutters, or by rolling colters on the plow used in digging. The sweet potatoes are then forked out by hand, or turned out by a moldboard, middle-buster, or special plow. Then they must be "scratched out" or lifted to the surface. They can be put directly on top of the soil with a mechanical digger, but there is some danger of bruising or skinning the sweet potatoes with this type of equipment if it is not carefully used. The dug potatoes are allowed to dry slightly so the adhering soil will come off. Then they are snapped from the stems, graded in the field, and placed at once in containers. They must be handled with care to avoid bruising. They should not be exposed long to bright sun.

Freshly dug sweet potatoes are less sweet than those which have been in storage a short while. The improvement during storage is due to an increase in the sugar and dextrin content at the expense of the starch.

Special storage houses have largely replaced the bank, pits or mounds used formerly. It is better to store the potatoes in the crates or tub baskets as brought from the field, rather than to pile them carefully in bins. The first step in successful storage is the curing. The temperature of the storage is raised to about 85° F. with 85 per cent relative humidity. It may take ten to fifteen days for curing to be completed, which can be judged by the appearance of sprouts. The cut surfaces become suberized or corked over and

wound periderm develops, which cuts down subsequent water loss and prevents entrance of decay organisms.

After the curing is completed the temperature of the storage should be dropped to 55° to 60° F. and the humidity kept at 80 to 85 per cent. This can be done by judicious use of the ventilators. Sweet potatoes will suffer chilling injury if exposed for two to three weeks to temperatures below 50° F. The lower the temperature the shorter is the time needed to produce the chilling injury. Cured sweet potatoes are less subject to chilling injury in storage than are noncured ones.

Properly cured and stored sweet potatoes can be held four to six months during the winter. The length of the storage period differs with varieties. A weight loss of not over 5 per cent is expected under proper curing conditions. This is followed by a loss in weight of 1 to 2 per cent a month in good storage. Losses from decay in storage may range from a negligible amount to a considerable one.

Sweet potatoes should not be resorted or handled while in storage owing to the likelihood of spreading rots. The potatoes should be carefully sorted as they are removed from the storage and packed for market. Hampers, baskets, and crates of one bushel capacity are generally used.

Yields of 100 to 200 bushels to the acre can be expected under proper conditions.

Insects and Diseases.—The beetle of the *Sweet Potato Weevil* feeds on all parts of the plant. The larvae burrow in the stems and roots in the field or may hatch in storage and there do their tunnelling. Sanitation, rotation, avoidance of weevil-infested seed potatoes or plants have been recommended. A 2 per cent dieldrin dust applied several times on and around the bases of the plants in the plantbed should aid in the production of plants free from weevils. The rate of application is 25 pounds to the acre.

Black Rot, which attacks the plant below ground, and affects the roots after they are stored, is one of the most important diseases with which the grower has to contend. The fungus is carried over winter in the soil and in diseased roots. Selection of disease-free seed is of primary importance. Rotation, seed treatment in bichloride of mercury, and a clean plant bed assist in control. *Stem Rot* is another disease generally present wherever the crop is grown, which causes a wilting, yellowing and death of the tops. The inside of the stem is brown. Long rotation, seed treatment and the use of seed potatoes from uninfested plants are recommended. The ultimate control will be the use of resistant varieties which at present are just beginning to be developed. *Foot Rot* develops as small dark spots on the lower part of the stem and often does not appear until mid-season. These spread and girdle the stem. It may cause a firm rot of the roots. Control is similar to that of black rot.

Soft Rot is responsible for much of the loss in storage. Avoiding injuries in harvesting, proper curing and storage conditions will reduce losses from the soft rot. *Ring Rot* is caused by the same organism and is controlled similarly. It differs in that a firm sunken lesion develops about the potato rather than the progressive soft rotting from one end to the other. *Scurf, Dry Rot, Southern Rot* and *Soil Rot* or *Pox* are other diseases encountered. Foliage diseases are seldom serious. *Internal cork*, supposed to be a virus disease spread by insects, shows as dark spots that increase in size and number during storage. Clean seed is suggested for avoiding this difficulty.

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Chapter 27

BEANS

THE common bean and the pole lima bean were grown in the New World before its discovery. The bush lima type was found in the United States during the latter part of the nineteenth century.

Besides these there are many kinds of beans that have limited use as human food. They vary a little in their temperature requirements but are essentially tender crops. The hyacinth bean, asparagus or yard-long bean, and the oriental types such as Mung and Adzuki are not extensively known. The Garbanzo or Chick pea, Tepary and Pinto are grown for dry ripe beans in the West and Southwest.

The soybean and the cowpea, which is really a bean, are important as soil-improving crops as well as having use as human food. Improved varieties of the cowpea, also known as the Southern pea, are used as fresh or processed green shell beans at a young stage. They are eaten also as a dry ripe bean. The culture of the cowpea is about the same as that of the soybean. The seeding rate varies from 20 to 45 pounds per acre depending on the seed size of the variety. Conch, Purple Hull, Blackeye and Crowder are popular varieties.

COMMON BEANS.

(*Phaseolus vulgaris.*)

Beans may be used as "dry," "green-shelled" or "snap" according to the stage at which they are harvested. In general, however, different varieties are preferred for the several uses. From the garden standpoint snap beans are the most important. Varieties are used for this purpose which have a somewhat fleshier-walled pod with less fibers in the younger stages. The dry-bean industry is an important source of food and is classed usually as a field crop. The kidney-shaped beans are not used as much for dry beans as the marrow, medium and pea classes, whose length is little more than their thickness. Shell beans are grown like the snaps but are gathered just before the large seeds begin to dry and harden. They are sold in the pod and shelled out before cooking.

Fertilization.—A well-drained soil should be used. Heavy clays and wet mucks are not suitable. The light loams will favor an early crop but soils more retentive of moisture should be used for

plantings which must develop during the summer. A loose, mellow seedbed is very desirable since the cotyledons of the seed are pushed up through the ground. A soil which may cake or crust badly before the seeds can germinate is obviously unsuited. Beans do not thrive on a very acid soil but yet are not considered a crop which responds much to liming.

Plowing under manure or a soil-improving crop is very beneficial for beans. If this is done then the quantity of fertilizer may be reduced about a fourth compared to that used where no such organic matter is incorporated. On sandy soils a 1:2:2 ratio seems

FIG. 75.—Prolific production of straight high-quality Tendergreen snap beans. (Courtesy Associated Seed Growers, Inc.)

to be preferred. The rate of application should supply about 25 to 75 pounds of nitrogen depending on the level of the fertility of the soil. Beans on silt and loam soils are usually fertilized with a 1:2:1, sometimes a 1:3:1 ratio applied at a rate to supply 30 to 50 pounds of nitrogen to the acre.

In the western states 60 to 100 pounds of nitrogen is used alone on sandy soils and 40 to 60 pounds on heavier ones. Soils that are known to be low in phosphorus should receive an application of abut 100 pounds of phosphoric acid per acre. There are soils in the North-west where beans have responded to the use of complete fertilizers of ratios similar to those suggested for other parts of the country.

Placement of the fertilizer for beans has given better results than broadcasting. The bands should be 2 to 4 inches away from each side of the row and 1 to 2 inches deeper than the seed.

Side-dressing with 20 to 30 pounds of nitrogen to the acre in a readily available form is justified if growth is slow.

Propagation and Culture.—Bush beans are planted in rows by hand or with a seed drill. In the case of extensive plantings, a corn planter with bean plates, or a grain drill with some of the feed cups blocked may be used. Nothing is to be gained by hill plantings except where cross cultivation is necessary on very weedy

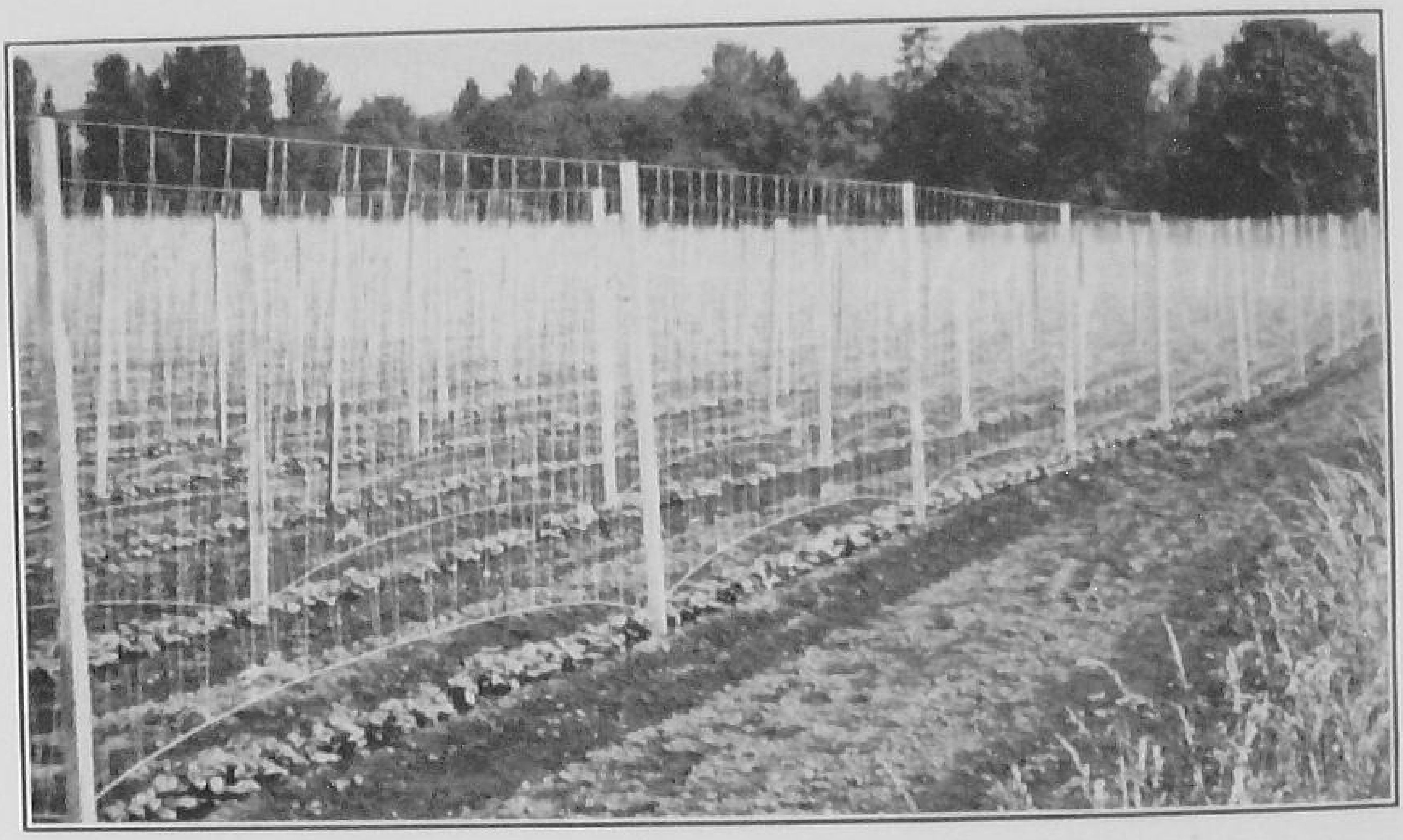

FIG. 76.—A string and wire support used for Blue Lake pole beans in Oregon.

land. The rows may be spaced 24 to 36 inches apart. A space of 2 to 3 inches between plants in the row is about right for all except the rankest growing. Usually 40 to 80 pounds of seed are required to plant an acre depending on the spacing of the rows and the size of seed of a given variety.

Pole beans are planted in hills or drills. The hills or spots can be 1½ to 2 feet apart with 3 to 5 feet between rows, and then three or four plants left at each place. When drilled in rows a plant can be left every 6 to 8 inches. Poles are placed at each hill, or at 1 to 2 foot intervals in the row, or some sort of trellis of wire and strings provided. About 25 pounds of good seed per acre is enough for pole beans. Because of the habit of germination deep planting is to be avoided, except in dry, light soil. A depth of 1 to 2 inches is ordinarily sufficient. When beans are planted in cold, wet soil it may pay to treat them with Spergon or Arasan.

The stems of the climbing beans may twist or twine about supports in a counter-clockwise direction.

Bean seed will fail to germinate satisfactorily in cold soil. The crop is injured by frost. Therefore, it is safest to wait until about the time of the last spring frost before the main plantings are made. There is no harm in hazarding a small planting before this date. If the weather is favorable an early harvest may result. Very high temperatures will cause blossom drop or short curved pods containing few seeds. This is due to the production of non-functional pollen grains which fail to fertilize the blossoms properly.

A few shallow cultivations are necessary for the purpose of weed control before the plants cover the ground. When the foliage is wet it is best to keep away from the bean patch to avoid spreading the spores of the anthracnose fungus.

The roots will remove moisture from a depth of about 4 feet when there is no hardpan to prevent their growth downwards. Usually irrigation is needed to keep the whole root system functioning unless periodic rains occur.

Varieties.—There are a multitude of varieties from which to select. Bush and pole beans are of two types; the green podded and the wax or yellow podded. Some are rather rounded in shape, others flat. Market demands vary in respect to color and shape. Bush beans bear earlier and for a shorter period than pole beans. The dwarf types mature in forty to fifty days and the pole varieties in seventy to eighty days.

Dwarf Types.—Bountiful and Plentiful have flat green pods while Stringless Black Valentine and Tendergreen have rounded pods. Cherokee Wax with oval pods, Sure Crop Wax with flattened pods and Brittle Wax with round pods are the best of the yellow-podded sorts. French's Horticultural and Dwarf Horticultural are good varieties for green-shell use.

Varieties with resistance to certain diseases are appearing which may replace some of the older ones. Wade, Topcrop, Contender, Logan and Tenderlong 15 with oval or rounded pods are among the new varieties of promise.

Pole Types.—Stringless Blue Lake and the White-seeded Kentucky Wonder strains are the best quality pole beans. Horticultural or Speckled Cranberry is desirable for green-shelled beans. Columbia has resistance to curly top and mosaic.

Harvesting.—Beans may have fibers in the side walls or "strings" in the sutures. Both of these conditions lower the quality. Varieties desirable for snap-bean production should not have this side wall condition but rather be quite fleshy. If harvested while the pods are still growing they will be stringless. The seeds will be partly developed but not particularly evident from the outside of the pod.

It is necessary to make several pickings at such intervals as will permit the highest quality of harvested product. Pods showing evidence of disease or injury should be discarded. The yield of bush beans will be from 100 to 300 bushels (30 pounds) to the acre. Mechanical picking of bush beans may be feasible with machines now being developed. A variety with erect growth and a concentrated maturing of pods borne well off the ground seems necessary for success.

Pole beans are picked more times than bush beans. An acre may yield 5 to 8 tons or more. Green-shell beans of the bush or pole type are allowed to develop further than snap beans, but must be gathered before the pods and beans begin to dry.

FIG. 77.—Snap beans infected with Bean Anthracnose.

The pods are allowed to become fully mature and dry for the dry bean crop. The plants are mowed off near the ground level, dried and thrashed. All discolored, cracked or imperfect beans should be removed as the beans are cleaned after thrashing.

Insects and Diseases.—The *Bean Weevil* does its damage in storage. Eggs are laid in the pods and the weevils cut their way out after the seed has been harvested, leaving a cylindrical hole. Germination of injured or infested beans is reduced. For control see discussion under seed treatment in Chapter 13.

Flea beetles, Spider Mites, Leaf Hoppers and *Thrips* may need to be controlled. Usually a 5 per cent DDT dust plus sulphur will be effective. DDT should not be used within a month of

harvesting. A combination of rotenone and DDT will control the insects listed above as well as *Aphids* and some types of *Beetles*.

Seed Corn or *Bean Maggot* may be troublesome in a cold late spring, attacking the seedlings before they get above the ground. Early plowing of the land for beans, shallow planting and late planting are suggested for control. Seed treatment with a combination of a fungicide and lindane, dieldrin, aldrin or heptachlor, used according to manufacturer's directions, gives good control

The *Mexican Bean Beetle* is lemon to copper colored with 16 black spots in 3 rows across its back, It is about ¼ inch long. The larvae are yellow with black spines which make them resemble tiny porcupines. Sanitation and plowing the vines under right after harvest help reduce infestation. Treatment must begin as soon as larvae are found on the under sides of the lower leaves, or when the characteristic lace-like feeding marks are seen. The safest material to employ and the easiest to blow onto the under sides of the leaves is a ¾ of 1 per cent rotenone dust. One can spray an acre of beans with 100 gallons of water containing 2½ pounds of a 5 per cent rotenone powder.

The organic phosphates are effective on this insect and others but must be used with extreme caution. Malathion will control the bean beetle as well as aphids, leaf hoppers and mites if they are present.

Anthracnose affects all parts of the plant. Rather circular black sunken areas which later may become pink in the center develop on the pods. On the leaves similar areas are confined to the petioles and veins. Although commonly called rust, it differs greatly from the true rust disease. The fungus is carried from year to year on the seed and on diseased plant refuse. Disease-free seed, rotation and keeping away from the plants when they are wet will aid. Several strains of the fungus have been determined and varieties of dry field beans developed which are resistant to one or more of the strains of the pathogen. Work of this sort is under way with snap beans and offers the best solution to the problem of control.

Bacterial Blight is found on the leaves, stems, pods and seeds. On the leaves it is much more conspicuous than anthracnose, for it forms large dead areas which are thin and brown. On the pods small irregular spots with a water-soaked appearance and red margins can be noted. This disease often causes a serious girdling of the stems. Disease-free seed, rotation and not touching wet plants are suggested methods of control.

Rust is more serious in the South. It is principally a foliage disease but may be found on the pods. It is characterized by numerous small pustules as large as the head of a pin. These break open and discharge a rusty-brown powder. Many varieties possess

considerable resistance. Spraying or dusting with sulphur is a preventative measure where rust is a problem.

Powdery Mildew may cause damage in humid weather. There are several strains of the fungus. Varieties such as Wade, Logan, Ranger, Florida Belle, Seminole and Tenderlong 15 are among those having some degree of tolerance.

Mosaic is carried over in the seed and probably spread from plant to plant by insects. Clean seed should be used. There are many snap bean varieties that are resistant to the common bean mosaic and a few to the New York 15 strain of mosaic.

LIMA BEANS.

(P. lunatus.)

A frost-free growing period of at least four months with warm nights during this time is necessary if large yields are desired. Hot dry weather seems to reduce the set of pods. A light soil will stimulate early growth and maturity. The first pods should be ready for picking in eighty-five to ninety days. Where there is a long season the heavier soils may yield a larger crop because they will dry out less. Irrigation is a valuable means of increasing yields. The seedbed must be mellow and prepared especially well because of the large size of the cotyledons which must be pushed to the surface. A richer soil is required than for kidney beans. Readily available fertilizer will hasten growth, but excessive applications of nitrogen are thought to increase the foliage development and delay fruiting.

On fertile soils a fertilizer analysis with a 1:2:1 ratio used in such a quantity as will give about 30 to 40 pounds of nitrogen per acre is usually adequate. If the soil is sandy, has not been well fertilized in the past, or if no manure or soil-improving crops have been incorporated then a 1:2:2 ratio is preferred. The rate of application should supply about 50 to 75 pounds of nitrogen to the acre.

In some areas, especially in the West, from 80 to even 160 pounds of nitrogen per acre alone or in combination with 40 to 80 pounds of phosphoric acid has been profitable. The higher rates would be used on new land or where the soil fertility is low.

The placement of the fertilizer bands must be such that there is no injury to the germinating seed. If the fertilizer is banded it should be placed 2 to 3 inches from the sides of the row and at 2 to 4 inches greater depth than the seeds. Some growers prefer to plow down the fertilizer rather than chance the injury that might occur from band placement.

Propagation and Culture.—Seeds will not germinate well until the soil temperature is above 65° F. The lima bean is not easy to transplant, but in order to lengthen the season it is possible to start seed in some sort of pot or container under glass for setting in the garden three or four weeks later. This shift must be delayed until all danger of frost is past.

Fig. 78.—A bush lima bean plant.

Drills are available which drop the seed at intervals of 3 to 5 inches in the row and at a depth of 1 to 2 inches. It is not necessary that the hilum or scar be downward in the soil. The bush types are planted in rows 2 to 3 feet apart, while those of the pole varieties should be 4 feet. Poles or a trellis are needed to support the climbing varieties to facilitate harvesting. When the pole varieties are grown for freezing or as a dry bean crop in California the rows are spaced 30 inches apart and the vines allowed to spread over the ground.

The quantity of seed needed to plant an acre varies with the variety. The small-seeded types, dropped 4 inches apart in 30-inch rows, require about 50 pounds an acre while the large-seeded varieties would take twice that much. If the rows of pole lima beans are spaced 4 feet apart then 20 to 50 pounds of seed are needed to plant an acre for the small and large-seed varieties respectively.

The lima bean will absorb water from a depth of 6 feet if the roots can penetrate the soil that deeply. Thus a considerable reservoir of soil moisture is available. However, depending on the rate of evaporation, the soil may need to be refilled with water several times during the season, either by rain or irrigation.

Varieties.—Most of the important varieties have white seeds but there are others with mottled or speckled seeds. The climbing types are later maturing than those of bush habit. Henderson Bush and the Carolina Sieva or Butter, a climber, have small flat seeds. Baby Potato and Baby Fordhook are dwarf varieties bearing small thick beans. Peerless and Fordhook 242 have thick medium-sized beans. The latter sets pods well under high temperatures. Burpee's Improved Bush has large flat beans while Concentrated Fordhook and Fordhook Bush produce large thick beans. King of the Garden, with large flat beans and Challenger which has large thick beans, are the most popular climbing varieties.

Plant breeders have been active in developing varieties with green cotyledons that will be adapted to the frozen bean industry. Green-seeded Henderson, Evergreen, Clark's Bush, and Cangreen are some of these new sorts.

Harvesting.—Bush and pole limas are picked for use when the pods are about full grown but have not begun to yellow. Several pickings are needed to gather the crop. Pole limas continue to yield until killed by frost.

The vines of green limas for freezing and canning are mowed and picked up by or carried to a viner which beats out the beans. These must then be rushed to the processing plant. The dry lima crop is mowed when the pods are yellowed. The vines are dried in windrows. A pick-up thresher separates the dry beans. The yield of fresh limas will average between ½ and 1 ton of shelled beans or 50 to 100 bushels of pods per acre.

The fresh green lima beans will reach the consumer in better condition if left in the pods, but some markets still demand that they be shelled and offered for sale in pint baskets. This hand work is expensive for the market grower. Mold is likely to develop on the shelled beans if they are not allowed to dry well before the baskets are enclosed in any container.

Insects and Diseases.—The *Downy Mildew* appears as a white mold on the pods. Plenty of moisture, with hot days and cool nights favor the mildew. Rotation, sanitation, clean seed, wide spacing so the vines dry quickly will help but may need to be supplemented with applications of 4:4:50 Bordeaux mixture or a 6 per cent low-soluble copper dust. The dithiocarbamates are recommended also.

Wireworms and *Seed Corn Maggots* can be controlled by the seed treatment suggested under Common Beans. EDB, DDT and aldrin are effective as soil treatments ahead of planting.

MULTIFLORA BEAN.

(*P. coccineus.*)

These beans differ from our common types in two striking characters. The cotyledons remain below ground in germination and the flowers are borne in rather large clusters. There are dwarf and climbing types.

The Scarlet Runner is a useful ornamental but the young pods, green and dry seeds may be eaten. The White Dutch Runner is grown in many places under the name of "Butter Bean" as a substitute for the lima although not of as high quality. It is very productive and may be planted earlier. The green-shell seeds are large and fleshy.

The culture of the multiflora bean is similar to that of the pole kidneys.

SOYBEAN.

(*Glycine max.*)

The edible soybeans can be used as green shell beans or as dry beans. They have a rich distinctive flavor and are high in food value. The soybean is a warm season, moderately deep-rooted crop.

A warm even temperature with fair humidity is desirable. The soybean can be planted in the spring when the soil is warm enough for corn but still too cold for snap beans. The soil should be fertile and well prepared. A fertilizer with an analysis of about 1:2:2 ratio applied at a rate to supply 10 to 15 pounds of nitrogen will usually suffice.

The rows should be spaced 30 to 36 inches apart with the seeds dropped at 2 to 3 inch intervals. It takes 60 to 90 pounds of seeds to plant an acre depending on the size of the seeds. On heavy soils a planting depth of 1 inch is preferable while on light soils the seeds can be put in at a 2 to 2½ inch depth. Weeds should

be controlled. Irrigations will be needed if there are no summer rains.

There are many varieties. Those usually recommended are Green Giant, Bansei and Sac for early, Kanro and Hokkaido for mid-season, with Edsoy and Jogum for late harvesting. It is best to plant varieties from each group at the same time to prolong the harvesting season instead of making several plantings of one variety.

The beans will reach the green-shell stage in one hundred to one hundred and twenty days. Pods will be suitable for picking from any one variety over a period of about two weeks. Parboiling for five minutes makes shelling of the green beans easier.

After the beans pass the green-shell stage, they will ripen and may be harvested as dry beans. Since they shatter severely it is necessary to harvest the crop before the pods have dried. Yields should average 1000 pounds or more of green shelled or dry beans per acre. Grasshoppers and rabbits are the most serious pests.

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Chapter 28

THE SOLANACEOUS FRUITS

There are four important members of the Solanaceae Family. One of them, the potato, differs in that its edible product is developed underground. It has been discussed previously in chapter 24. The more or less fleshy fruit is the part eaten in the case of the other three—Eggplant, Pepper and Tomato. The Garden Huckleberry and Husk tomato are minor crops of interest. Not only are these fruit crops related botanically but their culture is quite similar.

They are grown as annuals. If not killed by disease they bear until frost. Early seeding under glass for later transplanting to the garden increases the length of bearing season and therefore the yield. They are tender crops and should not be set in the field without protection until danger of frost is past.

EGGPLANT.

(Solanum melongena.)

India is probably the native habitat of the eggplant. The history of its culture is rather confused, but it has been used no doubt in the tropical countries for several thousand years.

Continuous rapid growth of the plants is necessary throughout their life. A very warm season is needed for profitable commercial culture.

A light warm soil such as a sandy loam well supplied with organic matter should be selected. It is preferable that it be rich already but the natural fertility may be supplemented further by the use of a fertilizer with a ratio of 1:2:1 or 1:2:2. This should be used to supply about 50 pounds of nitrogen to the acre. Since eggplant is a long-season crop a side-dressing with 30 pounds or so of nitrogen to the acre in readily available form midway in the growth period is desirable. Eggplant is moderately tolerant to soil acidity.

Propagation and Culture.—The seeds are planted eight to ten weeks before the beginning of the frost-free period. The young seedlings are not rapid growing in comparison to those of tomato. The final transplanting under glass should be into some sort of pot

or other container. A fairly rich potting soil is needed. An occasional watering with liquid manure or nitrate solution may be needed. If the plants are not suffering from crowding of roots or tops it is well to keep them under glass until the weather is warm, even though frost danger is over.

In the field they are set 2 to 3 feet apart in rows spaced at 3 to 4 feet, except that the small growing New Hampshire variety should be put at closer spacings. Clean cultivation should be given.

Varieties. There are a number of the smaller and narrower fruited varieties but they are of little importance. Black Beauty is the most generally grown. It has blocky dark purplish fruits. New York Improved Spineless is a little later, with more elongated, lighter purple-colored fruits. Early Long Purple and New Hampshire Hybrid are earlier maturing and therefore adapted to Northern sections. Fort Myers Market and Florida High Bush are popular in the South. Certain true F_1 hybrids such as Black Magic are available.

Harvesting.—The fruits may be cut from the plants just as soon as they are large enough. This may be when they are one third grown. Fully matured fruits are not as desirable as those somewhat immature, but fully developed "eggs" may remain on the plants for some time with little deterioration. In harvesting the calyx and stem are left on. Careful handling is necessary to avoid bruising or injuring fruits on the stems of others. An acre should yield on the average from 300 to 400 bushels of "eggs."

Insects and Diseases.—*Red Spiders, Potato Beetles, Flea Beetles* and *Aphids* attack eggplant.

Eggplant Wilt is a serious disease for which no control exists. It is less important in the warmer parts of the country. The fungus persists in the soil. Rotation, and avoiding contamination of seedbeds and new fields are important. The wilt is reduced at a soil reaction of pH 5.0 to 5.5. *Blight* and *Fruit Rot* are caused by a fungus which attacks all parts of the plant. Spots appear on the leaves, the stem may be infected near the ground or the fruit may rot. Losses of this latter nature are severe in wet seasons. The fungus is carried over winter in the soil, in trash, on and in the seed. Sanitation, rotation, seed treatment with hot water at 122° F. for twenty-five minutes, then drying and treating with red oxide of copper are recommended. A clean seedbed soil will assist in control. Weekly spraying of plants in the plant bed with Zerlate and in the field with Manzate, both at 2 pounds to 100 gallons of water, has been suggested when the disease is likely to be severe. Varieties such as Florida Market and Florida Beauty are resistant to this Phomopsis disease.

PEPPER.

(Capsicum annuum.)

The garden pepper belongs to a different botanical family from that of the black pepper of commerce. Mild-fleshed peppers are used for salads, stuffing, pickles and some are dried for grinding into paprika. The more pungent types serve for relishes, pickles, seasoning and sauces. The pepper is a native of Tropical America and without doubt was in use many years before the discovery of the New World.

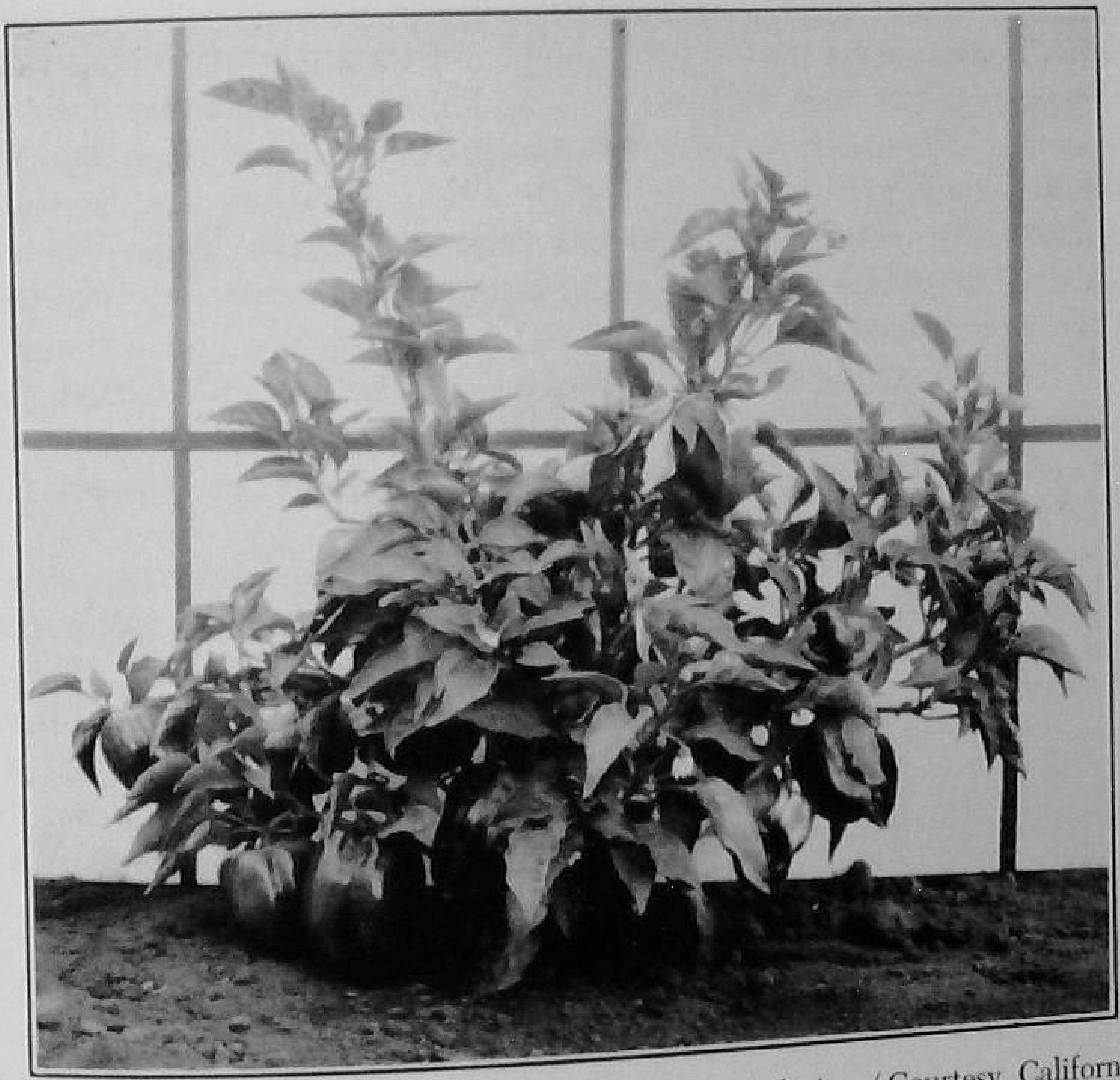

FIG. 79.—A pepper plant bearing a good crop of fruits. (Courtesy California Agr. Exp. Sta.)

This crop will do well under a wider range of temperature and moisture than eggplant or tomato. High temperature results in a poor set of fruit. Sandy or silt loams retentive of moisture are perhaps better adapted than the heavier soils. Ample nutrients will be provided on most soils if a fertilizer with a ratio of 1:2:2 or 1:2:1 is applied at a rate to supply 30 to 50 pounds of nitrogen. Addi-

tional side dressings of nitrate may be deemed necessary if growth lags. A moderately to slightly acid soil seems best for peppers.

Propagation and Culture.—Peppers may be started early in hotbeds, coldframes or open plant beds. In California much of the crop is seeded directly in the field. The choice of method depends on local climatic conditions and when harvest is desired. It takes eight to ten weeks in the plant bed to grow a sturdy, well-developed plant. About ½ pound of seed will produce enough good plants to set an acre. Direct field seeding is usually at the rate of 2 to 3 pounds per acre.

Under glass or in covered beds the seed can be sown first and the seedlings transplanted into flats, or sown in 4 to 6 inch rows where the plants develop to field-setting size without transplanting. They should not be moved to the field until danger of frost is past.

Pepper plants are well-adapted to being set by transplanting machines. The use of a starter solution in the water at transplanting will help them get off to a good start. The rows should be 36 to 42 inches apart with 18 to 24 inches between plants, regardless of whether the plants are transplanted or thinned to this spacing from a direct field seeding.

Weed competition must be prevented by shallow cultivation. Irrigation, either sprinkler or furrow, is helpful in giving a steady rate of growth and maintaining sufficient foliage to protect the fruits from sunscald.

Varieties.—There are a number of desirable varieties of the large-fruited sorts. Breeding work promises to produce others. Vinedale and Pennwonder are early, prolific but with small fruits. World Beater and the Ruby King types have large elongated fruits. There are several thick-fleshed varieties of the California Wonder type, which mature more quickly than the California Wonder and so are adapted to sections which do not have a long warm season. The Wonder type is the most popular for market.

Perfection or Pimiento is used for canning. Hungarian Paprika is grown some for drying to make paprika powder. The Anaheim and Mexican Chilis are planted for the production of Chili powder. Long Red Cayenne, Floral Gem, Red Cherry, Hungarian Wax, Red Chili and Tabasco are pungent peppers.

Harvesting.—The large Bell peppers are usually harvested when they have reached sufficient size but are still green in color. There is a demand in some markets, especially in the canning season, for red-colored fruits. They may be left on the vine with little loss in quality until they begin to change color.

The pimiento, paprika and chili peppers are not harvested until the fruits are completely red. Three or more pickings may be needed to harvest the crop.

The stems of the fruits can be snapped quite readily by an upward twist. A good average acre yield for market peppers is 300 to 400 bushels and for pimientos, paprikas and chilis between 3 and 4 tons.

Insects and Diseases.—In some parts of the country severe losses are caused by the *Pepper Weevil* and *Pepper Maggot*. Sanitation and eradication of the wild host plants, nightshade and horse-nettle respectively, will help control these insects. A 50 per cent cryolite dust or a 5 per cent DDT dust have given effective control, but should not be used during the month preceding harvest. *Aphids* can be held in check by applying rotenone or nicotine along with the cryolite or DDT.

Pepper is attacked by many organisms which cause spotting of the leaves and rotting of the fruits. Seed treatment and the use of sprays or dusts containing copper or one of the dithiocarbamates such as zineb, ziram or nebam.

Virus diseases such as the *mosaics* and *spotted wilt* are spread by aphids and thrips respectively which are difficult to kill before they have transmitted the virus to previously healthy plants. Yolo Wonder, and the Burlington and New Jersey No. 13 strains of World Beater are resistant to mosaic.

TOMATO.

(Lycopersicon esculentum var. commune.)

A native of Tropical America, the tomato has come to fill an important place in our diet. Although there is some evidence that it was used by the people of the New World long before the coming of the Spaniards, even at the beginning of the nineteenth century it was considered poisonous by many persons, and thought to be useful only as an ornamental. The tomato is the second most important vegetable in the United States.

Tomatoes are used in juice, salads, soups, preserves, pickles, sauces, catsup and served cooked in many forms.

A warm growing season with plenty of sunshine and adequate moisture is necessary. Outside planting must be delayed until frost danger is over unless plant protectors of some sort are used. Minimum night temperatures above 59° F. are required for fruit set. Ripening takes place forty-five to fifty days after pollination.

Fertilization.—A well-drained, but not dry soil is best for heavy yields. This necessitates a good content of organic matter. The light porous classes, such as the sandy loams will aid early maturity. Silts and heavier loams are preferred for the main crop. Lime is usually of little benefit unless the soil is more than moderately acid.

Too much nitrogen with reduced sunlight will stimulate excessive

vine growth and blossoms may not develop satisfactorily. A side dressing of about 20 to 30 pounds of available nitrogen an acre given when the first cluster of fruit is set will stimulate growth and increase the yield. Phosphorus appears to be of great importance in relation to the setting of fruit. Fresh manure is not desirable as it may delay maturity unless applied the previous fall. Rotted manure can be used in soils deficient in organic matter. Soil-improving crops can precede tomatoes but their decomposition should be speeded by applying 50 pounds of nitrogen to the acre before plowing.

In most parts of the country on sandy soils an analysis with a ratio of 1:2:2 is preferred for tomatoes. The rate of application to an acre should provide 50 to 100 pounds of nitrogen according to the fertility of the particular soil. On silt and loam soils the ratio can be from a 1:2:1 to a 1:4:4 applied to supply somewhat less nitrogen than on sandy soils. If manure is used a 1:3:1 should be substituted for those mentioned. Tomatoes grown on trellises or stakes must receive a heavier application of fertilizer than those produced on the flat because of the increased population of plants.

In contrast to these recommendations for humid areas, tomatoes grown on the unleached soils of the semi-arid West will be adequately fertilized if the application supplies 50 to 100 pounds of nitrogen and in some places the same quantity of phosphoric acid. Part of this nitrogen can be given in the irrigation water.

The heavy demand by the plants for nutrients occurs in the later stages of growth. To meet this it is wise to plow down ½ to ¾ of the fertilizer before planting. The remainder, but not more than 500 pounds to the acre, can be put in bands 3 or 4 inches on each side of the plant row and at a depth of 4 to 5 inches. Where the crop is grown on light soil or subject to excessive leaching it is well to hold part of the fertilizer for a subsequent side-dressing when the fruits are partly developed.

Starter solutions, like the 10:52:17 or 15:30:15, applied in the transplanting water are very effective in stimulating early growth on many soils.

Propagation and Culture.—Well-grown plants are essential for the production of profitable yields. These are started in some sort of plant bed six to ten weeks before field setting. Too early planting should be avoided since the plants may have to be held back too long just before the final shift. Seed may be sown thinly and the plants not transplanted, or a somewhat thicker seeding used with one or two subsequent transplantings, according to the space available. The latter is the more common practice where early maturity and larger yields are desired, but the cost of each plant is greater and transplanting disturbs growth. If a second transplanting must

be given or when the space available necessitates only one the use of some sort of pot or container is advisable. The plants will suffer less check when shifted to the field. "Blocking out" of plants spotted 4 by 4 inches in a frame accomplishes practically the same result. The soil is cut between plants about a week before they are to be moved so that each may be shifted to the field in a block of soil and compost with little disturbance of the roots.

The time needed for the plants to reach proper size depends on whether they are transplanted, grown with or without heat, and on the prevailing weather conditions. When the plants are grown in a frame or bed without transplanting the rows are spaced 4 to 8 inches apart, and the seeder adjusted to drop 20 to 25 seeds per foot of row. This will give about half that number of plants. Some thinning of clumps may be needed. In some parts of the country tomatoes are seeded directly in the field with later thinning to the desired row spacing. An ounce of seed will give plenty of transplants for an acre, while 5 or 6 ounces to the acre will provide enough plants in direct field seeding.

Experiments indicate that low temperatures or water shortage result in the later development of wrinkled tomato fruits. Since early tomato plants are grown in such a manner that they may be set in the field without severe disturbance of the roots, proper adjustment of the water supply and temperature in order to avoid too succulent growth may take the place of hardening. If each plant is covered with a paper plant protector and care given to proper ventilation, planting may precede the frost-free date by a week or so, otherwise delay planting until danger of frost is over.

Stocky 6 to 10 inch plants are best. Those which are grown in containers or blocked soil are set by hand in holes or in furrows. The bulk of commercial plantings are put in with transplanting machines, the soil having been shaken from the roots as they are pulled from the plant bed. If the plants are to be staked they may be spaced 1½ to 2 feet in rows separated by 3½ to 4 feet. Untrained plants of most varieties should each have about 15 square feet of space. Common spacings are 4 by 4, 5 by 3, 6 by 1, 2 or 3 feet. Vigorous growing varieties on very fertile soil should have the greater spacings.

Training the plants on stakes or trellises by pinching out all but one or two of the laterals will give an increased early yield to the acre since the trained plants are spaced more closely than the untrained ones. There will be more early clusters of fruit from which the first harvests can be made. The total acre yield of the pruned plants may not be much different from that of the unpruned plants because of the reduction in top growth of the pruned plants.

The root system is decreased just about in proportion to the top. In a dry season this may react unfavorably, increasing the inability of the plant to replace rapidly enough the water lost from the leaves through transpiration. Thus more blossom end rot is developed. Sunscald and cracking are also likely to be increased with sparse foliage. It is easier to pick fruit from trained vines, but constant attention is necessary to keep them pruned and trained. In humid areas where the fruit is likely to rot from touching wet soil, training either with or without much pruning may be worth the cost.

The tomato has a wide-spreading root system. Shallow cultivation is necessary to control weeds, but care must be exercised to avoid root pruning, tearing of vines and knocking off the green fruit. Water can be supplied by furrow or overhead irrigation. When the latter is used the vines should be given time to dry off before night in order to reduce the spread of disease. The moisture in the soil reservoir should not be allowed to get down quite to the wilting point. The amount of water supplied by rain or irrigation for this normally deep-rooted crop will vary as the climate affects the rate of evaporation and the soil conditions influence root distribution and the quantity of water available in a particular soil.

When tomatoes bloom early in the season, cool temperatures may be unfavorable for fruit set. A hormone such as para-chlorophenoxyacetic acid can be sprayed on the early blossoms after bloom or as they open. Care must be taken not to get the hormone spray on the foliage because it will cause abnormal leaf growth. Fruits containing few if any seeds then develop from the sprayed blossoms and provide an early harvest. Rates of application of hormone sprays should be according to manufacturers' directions.

Varieties.—There are many varieties of tomatoes. Only a few are important. There is a great difference between strains of the same variety.

Varieties differ in their adaptability to temperature. Some will set fruit over a wide range while others will not. It takes about fifty hours or more for the pollen to germinate and the tube to grow down the pistil to the ovary. At low temperatures little pollen is produced. Below 50° and above 90° F. the germination and tube growth of the pollen is slow; thus at such temperatures the blossoms may drop off before fertilization takes place. Blossom structure is also a factor in fruit set. If the stigma protrudes very far beyond the anther cone, pollination may not take place.

Some varieties produce spreading vines, while Bounty, Pearson, Pritchard, Pennheart, Pearl Harbor and many others give a compact type of growth. They are determinate, *i.e.*, each stem ends in a flower cluster. The determinates can be planted at closer spacings than the indeterminates.

A considerable number of first generation hybrids have been released. New varieties resistant to certain diseases are constantly appearing. These should be substituted for the older varieties where disease conditions make this advisable.

Of the many varieties available the following which are of importance are grouped roughly on the basis of the time of the first commercial harvest. Some are grown for both canning and fresh market while others are limited to one or the other use. Pearson and Rutgers are the most important canning varieties.

FIG. 80.—Staking tomatoes is sometimes profitable. (Courtesy of Kilgore Seed Company.)

Early: Bounty, Valiant, Victor, Firesteel and the Earliana group.

Intermediate: Stokesdale, Grothen Globe, Pritchard, Pennheart, Earlypak, Marglobe and the Bonny Best group.

Late: Pearson, Stone, Rutgers, Indiana Baltimore, Red Jacket and San Marzano.

Harvesting.—Size is no index of the degree of maturity of tomato fruits. If the fruit is turning a whitish-green preparatory to showing color it can be handled and shipped with less damage than if more mature. Storage in light or darkness at 60° to 70° F. will develop

the pigments in a short time with practically the same quality of flesh as vine-ripened fruit. The fruits will not ripen at temperatures below 55° F. Above 80° F. the fruits become yellowish since the red pigment does not develop well. Cool temperatures in the field even though above the frost point may lead to subsequent poor ripening of the fruits.

Fruits for nearby markets may be picked when in the pink stage but those for canning should be ripe. Harvesting is accomplished by twisting the fruit loose from the calyx.

Yields may vary from about 4 to 18 tons. The variety, the purpose for which grown, the method of starting plants, the presence of disease, kind of soil, fertility and season are all factors concerned.

Insects and Diseases.—*Tomato Horn-worm* and *Fruit Worm* or *Corn Ear Worm* damage can be reduced by the use of stomach poisons as can that caused by *Pin Worms, Flea Beetles* and *Vegetable Weevils.* DDT is effective in insect control but may stunt the plants. DDD is recommended in some states. The *Russet Mite* is controlled by dusting with sulphur. Malathion also will control this mite as well as aphids.

Rotation and sanitation are of great importance in the control of diseases of the tomato. *Fusarium Wilt* persists in the soil. Rutgers, Marglobe, Pritchard, Pan America, and other varieties are more or less resistant to the disease. *Early Blight, Late Blight* and *Septoria Leaf Spot* attack the foliage. Spray or dust schedules using the insoluble copper compounds and the carbamates have been prepared by state experiment stations.

Bacterial canker is seed-borne. It causes decay of the stems and white spots on the fruit. *Damping-off* and *Bacterial Spot* may also cause trouble. The latter disease appears as black spots on the fruits and as small angular lesions on the leaves. For all three and *Anthracnose* the seeds can be treated with hot water at 122° F. for twenty-five minutes. The seeds should then be soaked in a solution of 2 ounces of copper sulphate to the gallon for one hour and spread out to dry. Just before planting Arasan or Phygon is dusted on the seeds at the rate of 1 level teaspoon to a pound of seed.

Anthracnose causes a rotting of the ripe fruit. Seed treatment, rotation and the use of fungicides as for the blights are the control measures. Various other rots will affect fruits which touch wet soil. Little can be done to stop them.

There are a number of virus diseases which cause a mottling or abnormal development of the foliage, or a spotting of the fruit. The viruses overwinter on many common weeds. The *Spotted Wilt* virus is spread by thrips, the *Curly top* virus by leafhoppers, the cucumber mosaic virus which causes *Fernleaf* by aphids, and the Psyllid yellows virus by psyllids. Control of the insects helps. The tobacco

mosaic virus causing *Tomato Mosaic* is spread by people handling the plants, as is a virus causing Streak. Usually this disease results when the plants are attacked at the same time by tomato mosaic and cucumber or potato mosiac.

Blossom end rot is characterized first by the death of the cells at the blossom end of the fruit enlarging sometimes to include half of the fruit. It is a physiological trouble seemingly due to the inability of the plant to obtain sufficient water. The maintenance of an uniform supply of soil moisture, and the avoidance of applying too much nitrogen are suggested as control measures. Marglobe and Pritchard are said to be less susceptible than other varieties.

In the West and Southwest the side of a tomato fruit exposed to the heating effect of the sun day after day may develop a condition known as *Gray-wall.* Along with the grayish color, the wall of the fruit may be thin because of the failure of the cells to expand. Thus this wall may rupture in handling. *Sunscald* and *yellow shoulders* are due to excessive exposure of the fruit to the heating effect of the sun, after the fruit has developed in the shade of the foliage.

HUSK TOMATO.

(Physalis pruinosa.)

The husk or strawberry tomato is a low-growing plant. It is related to the native "ground cherry" or Physalis. A berry about ¾ inch in diameter is produced inside a paper-like husk. The plants may be grown and handled like those of tomato. The fruits are useful in preserves and pickles, or can be kept many months in the husks. The flavor is much sweeter that the small-fruited tomatoes.

GARDEN HUCKLEBERRY OR WONDERBERRY.

(Solanum nigrum.)

This is the cultivated form of the black nightshade. The plants may be grown like those of the tomato. They bear numerous black berries about ¾ inch in diameter, which remain in good condition for several weeks after they ripen. They can be used cooked in pies or preserves.

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Chapter 29

THE VINE CROPS

The vegetables which fall naturally into this group are members of the same family. They are very tender and make poor growth until the weather is warm. In order to get earlier maturity and increased yields, seed of these crops may be started under glass four or five weeks before they can be set out. This may be especially valuable in regions with a short growing season. When started thus

Fig. 81.—A White Scallop summer squash plant showing the characteristically numerous male flowers produced by the cucurbits.

it is the custom to place several seeds in individual pots or bands, and later thin to the desired stand. It is possible, however, to drill the seeds in flats and transplant to the containers as soon as the cotyledon leaves are widespread. To avoid the possibility of a check in growth it is well to get the young plants out of the container into their permanent location soon after the fourth true leaf develops. There is often danger of root crowding if they are held longer. A plant of stocky growth will be less likely to suffer sunburning than a succulent one grown with too much water. Seeds or plants may be set out a little ahead of the normal time and

covered with a glassine or waxed paper cap or tent. Rigid plastic caps are available but require more care in the providing of ventilation than do the paper caps.

Most plants in this group produce separate male and female blossoms, however muskmelons and some watermelons have perfect flowers as well. The male flowers predominate. Although several of these crops are closely related species, it is doubtful whether interspecific crossing can occur, as for example, cucumbers with muskmelons or pumpkins with squash.

A preëmergence spraying of the cucurbits with Alanap-1 right after planting has given good weed control in some sections of the country. This material can be used as a post-emergence spray except on squash and pumpkin. Since soil conditions influence the behavior of Alanap it is important that the manufacturer's directions be followed strictly.

CHAYOTE.

(Sechium edule.)

The chayote is a cucurbit of minor importance cultivated in California and the South. The fruits are somewhat pear-shaped and have a delicate squash-like flavor when cooked. The whole fruit is planted and the vigorous vine trained up a trellis or arbor. A space of 10 to 15 feet or more is allowed each way between the hills. The tops are killed by frost, but in mild climates it is a perennial sending up new growth each year from the crown. The chayote is a short-day plant which does not begin to bloom until late summer. In the cool coastal regions of southern California it blooms earlier than in the warm central valleys. When the growth is not killed back during the winter months blooms may be produced in the spring before the days become long, thus giving a late spring harvest. It has separate male and female flowers.

Usually the plants will respond to irrigation and the application of available nitrogen at the rate of 50 to 100 pounds per acre. The fruits are removed from the vines as soon as they are large enough to meet market demands.

CUCUMBER.

(Cucumis sativus.)

This native of Asia has been cultivated for three thousand or four thousand years. The cucumber is one of the quickest maturing of the vine crops, and will grow fairly well at somewhat lower temperatures than melons. Larger yields can be expected on the heavier soils which are of greater fertility and moisture content.

Fertilization.—Well-rotted manure may be applied in moderate quantities under the row or a fork full placed under each hill if this method of planting is followed. Commercial fertilizer is valuable in stimulating growth. It is good practice on soils lightly manured or not manured to furnish 50 to 75 pounds of nitrogen to the acre in a complete fertilizer having a ratio of 1:2:2 on sandy soils and 1:2:1 or 1:3:1 on loams. The fertilizer may be plowed under or applied in bands 2 to 3 inches deeper than the seeds and 3 to 4 inches on each side of the row. Side dressings of nitrogen at 25 to 30 pounds per acre once or twice during the growth period are sometimes needed depending on seasonal conditions. Cucumbers are not particularly responsive to lime.

Propagation and Culture.—When plants are started under glass and two seedlings allowed to each container, hill planting in the field is perhaps easiest. The hills are spaced anywhere from 3 by 4 feet to 4 by 6 feet, varying with the vine vigor of the variety and fertility of the soil. A hill does not mean a mound except perhaps in low-lying land. Neither should the seeds be planted in a depression below the general level of the land. A dozen seeds may be planted in an area 6 to 12 inches in diameter. The seedlings are later thinned in one or two operations to two or three plants. This is insurance against a complete eradication of the hill by insects. Hill planting is necessary if paper plant protectors are to be used to advance the season.

If seed is placed where the plants are to mature drilling is simpler. The row of seeds can be placed in the soil over the furrow containing the rotted manure. The rows may be from 4 to 6 feet apart. Later the seedlings are thinned so that there are 12 to 24 inches between them. About 2 pounds of seed are required to plant an acre in this way.

Shallow cultivation may be given until the vines spread between the rows, but care must be taken not to tear the vines. Later a little hand work may be necessary in pulling large weeds.

Cucumber roots penetrate 3 or 4 feet into deep soils. Rain or irrigation is needed to keep moisture available in the root zone so that growth of the vines will be vigorous and the quality of the fruits unimpaired.

Varieties.—White and Black Spined types are used. Straight-8, Colorado, Cubit, Marketer, and Stays Green are among the best of the white-spined varieties. Improved Long Green is one of the best of the black-spined type. National Pickling, Snow's Perfection Pickling, and Chicago Pickling are prolific bearers.

Other varieties can be used when plantings are made under conditions where disease may be a problem. Santee is more resistant to downy mildew than is Palmeto. Niagara has considerable resis-

tance to mosaic, and Highmoor to scab. In the pickling group, Maine No. 2 is resistant to scab, Wisconsin SMR 12 to scab and mosaic, while Ohio MR 17, Ohio MR 25, and York State have considerable mosaic resistance. F_1 hybrids such as Burpee and Surecrop are available. They have considerable resistance to mosaic and downy mildew.

The West India Gherkin also is used for pickling. It belongs to a species different from the cucumber and has characteristic prickly fruit.

Harvesting.—The fruits should be cut from the vine as soon as they have reached marketable size. This necessitates gathering every day or two. Cucumbers must not be allowed to mature or the yield will be reduced. To be of good quality, the fruits should be firm, crisp and with seeds that have not become tough. All nubbins, poorly shaped or light-colored fruits should be picked and discarded.

When cucumbers are produced for pickling the smaller sizes are most desired. Those which reach a length of 4 or 5 inches sell for less money and are used as dill pickles. It is customary to "ribbon" the vines at the first harvest. This moving of all runners close into the row enables the pickers at subsequent harvests to roll up the vines and readily spot the pickles. They can thus make more speed.

If cucumbers are bitter it is likely that the plants have been short of water. Fruits produced later on the same vines will not be bitter if adequate water has been supplied in the meantime.

Cucumbers held below 55° F. suffer from chilling injury. This is evidenced when the fruits are moved to a higher temperature by accelerated deterioration, by increased susceptibility to decay, and by surface browning or pitting. The degree of injury increases with the duration of the exposure and how much the temperature is below 55° F. Less than two days in the chilling range is of little practical importance.

Yields depend upon the size at which the fruits are harvested and will vary from 200 to 600 bushels an acre.

Insects and Diseases.—There are a number of insects and diseases affecting the vine crops. Owing to the fact that Bordeaux mixture injures cucumber and muskmelon foliage, pathologists are searching for a fungicide which can be used as a substitute. Zinc dimethyl dithiocarbamate seems promising. DDT should not be used on vine crops because it stunts the vines and reduces yield.

The *Striped Cucumber Beetle* chews the plants and serves as a carrier for wilt and mosaic. Repeated treatments every five days with a 1 per cent rotenone dust will kill or drive away the beetles, or one may use a dust made of 1 part calcium arsenate in 15 parts

of gypsum. The *12-Spotted Cucumber Beetle* can be controlled in the same way. The nicotine treatment will control melon *Aphids*. The *Pickle Worm* larvae bore into the fruits and ruin them. They prefer the bush squashes, which may be scattered through the cucumber planting as a trap crop. *Squash Vine Borers* tunnel in the stems near the ground. Decay usually results. Control measures include rotation, cutting out borers, inducing rooting at the nodes and covering the stems thoroughly every 5 or 6 days with a 1 per cent rotenone dust which will kill the larvae and to some extent, repel the moths which come to lay eggs. The *Squash Bug* is a sucking insect. Sanitation, trapping under boards, hand picking and use of nicotine, rotenone, or pyrethrum sprays or dusts are recommended. Sabadilla or chlordane dusts are effective.

Bacterial Wilt losses are diminished by roguing of diseased plants and control of the beetles which spread the organisms from plant to plant. *Mosaic* results in stunting of the plants and fruits. The virus overwinters in the roots of ground cherry, pokeweed, milkweed, catnip and in the seed of wild cucumber. Beetles and aphids spread the disease. Control of the insects and a clean-up of the host plants are recommended. Resistant varieties are being developed. *Angular Leaf Spot*, a bacterial disease, appears as lesions on the fruit, as well as on the leaves and stems. It is carried over in the soil and on the seed. Rotation, sanitation, soaking seed for five minutes in 1 to 1000 bichloride of mercury solution with rinsing and drying, and systematic use of fungicidal sprays or dusts will check the disease. *Anthracnose* causes brown lesions on all parts of the plant. *Scab* produces cankers on the fruit. They are severe at relatively high temperatures and in wet seasons. Control measures are similar to those for angular leaf spot. *Downy Mildew* can be controlled by spraying or dusting as for anthracnose and leaf spot. Varieties which are resistant to these diseases are appearing.

Powdery Mildew has been controlled by frequent dusting with a combination of 7 per cent metallic copper and 15 per cent sulphur, or with 6.5 per cent zineb or 7 per cent ferbam. Copper dusts are not too effective on angular leaf spot or anthracnose, nor is ziram on downy mildew and angular leaf spot. Manzate is recommended for all these cucurbit foliage diseases and zineb for most of them.

Mice often devour seeds in the field before germination is complete. A few old or fresh seeds may be soaked in a strychnine solution and placed near each hill. The seeds are left over night in the solution made by dissolving in a quart of warm water a quantity of strychnine about equivalent to a dry wrinkled pea. This poison must be used with great care.

MELONS.

There are three crops sometimes known by this general name but it belongs more properly to the first two which are members of the species Melo. While in the Wilderness the Israelites lamented concerning the melons and cucumbers which they recalled having eaten in Egypt.

Muskmelon.

(Cucumis melo var. reticulatus.)

Although the term "cantaloupe" is applied quite generally in the United States to the netted melon, such use is incorrect. The true cantaloupe has a warty exterior and is scarcely known in this country. It is believed that the original habitat of the melon was in southern Asia, and that some forms at least have been cultivated from a remote period.

A frost-free period of one hundred and twenty days is desirable and should provide warm days and nights. Adequate soil moisture should accompany the warm temperature. Dry, warm weather at harvest is conducive of high flavor and quality.

Fertilization.—A well-drained soil that is in good tilth and well supplied with organic matter, such as a sandy loam or silt loam will be found most suitable. While not classed as a high response crop to liming the muskmelon thrives best on a soil that is only slightly acid. Well-rotted manure may be placed under each hill or row. It is well to supplement it with 50 to 100 pounds of superphosphate to each ton of manure. If manure is not supplied, then a green manure crop should precede the melons. The fertilizer used with little manure ought to furnish, on light soils, about 50 to 80 pounds of nitrogen and 100 to 160 pounds of phosphoric acid and potash:—for example, 1000 to 1600 pounds of 5:10:10 or 4:12:8. On silt soils, the potash can be reduced to the quantity indicated for nitrogen. The wide-spreading root system will obtain broadcast fertilizer, but early growth is stimulated when less than 500 pounds is used, if this amount is placed near the rows. A side-dressing of 15 to 20 pounds of nitrogen per acre, given as the vines begin to run, usually proves profitable.

In the cantaloupe districts of Arizona and California 60 to 100 pounds of nitrogen to the acre is applied in a band between the furrow and the seeded row. Half this quantity can be used at planting and the remainder as the runners start. This later application is often supplied in the irrigation water. On soils known to be low in phosphorus 60 to 120 pounds of phosphoric acid to an acre are

worked into the soil as the beds are shaped or drilled between the seed and the irrigation furrow.

Propagation and Culture.—Plants started under glass make harvest more certain in the North. Paper caps are used on much of the early commercial plantings in the Southwest. Cantaloupe seed germinates poorly when soil temperatures are 60° F. or lower. The plants are very tender. Therefore planting must be delayed if protectors are not used until the soil is warm and frost danger is past.

Seed can be planted in hills at 2 to 5 foot intervals in rows 5 or 6 feet apart using a pound or two of seed to the acre. The plants are thinned to one or two to the hill depending on the hill spacing.

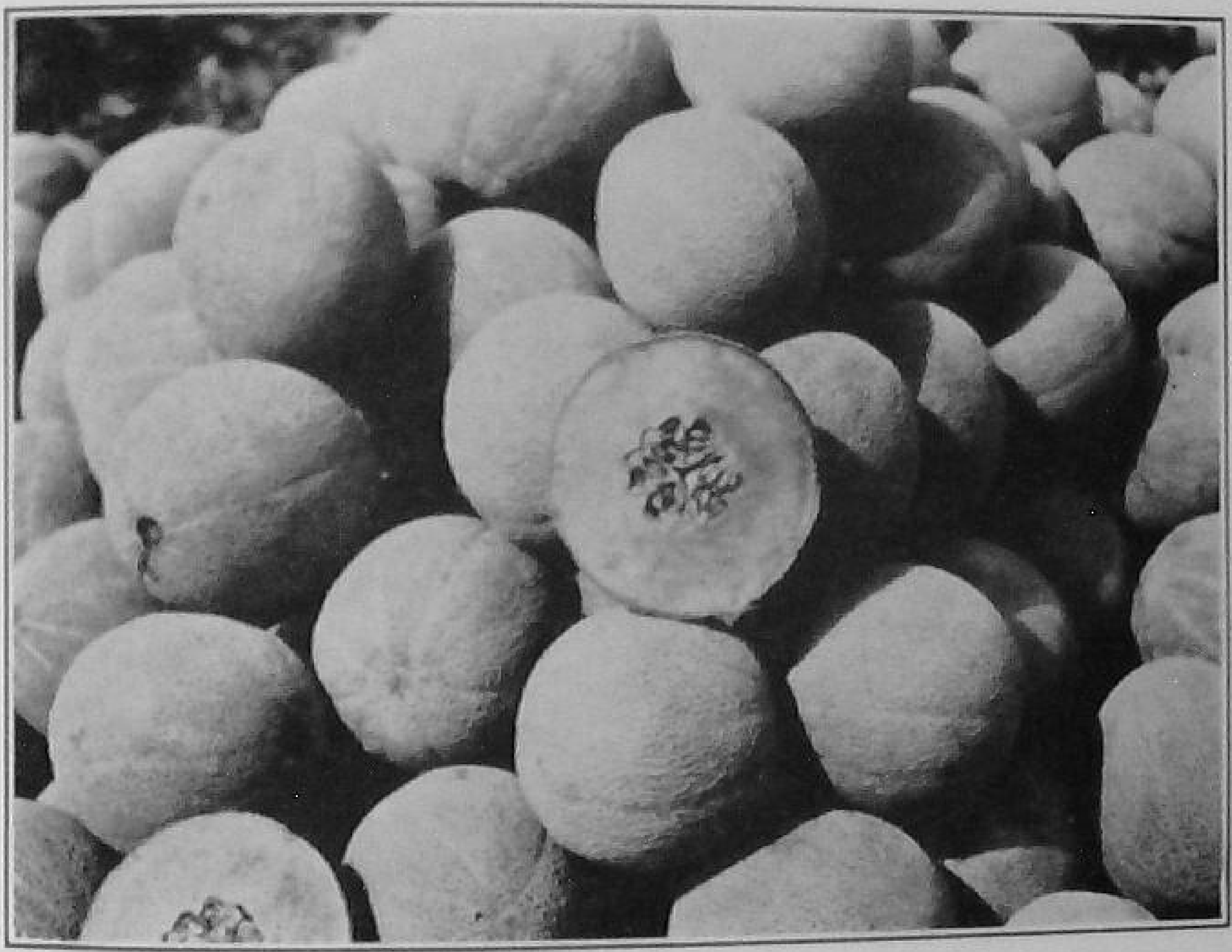

Fig. 82.—A pile of uniform Superfecto muskmelons. Heavy netting, thick meat and small seed cavity denote the high quality of this variety. Full maturity is indicated by the hollowed-out stem end or "full slip" where the stem is pulled away. (Courtesy of D. V. Burrell.)

Much of the open-planted crop is drilled in rows 5 to 7 feet apart using 1 to 3 pounds of seed to the acre. In semi-arid areas the drilled row can be placed along the edge of an irrigation furrow or one is opened as the row is planted.

The plants in drilled rows should be thinned to a single stand at intervals of 1 to 3 feet or two plants left at spacings of 3 to 5 feet. If vigorous vine growth is expected the wider spacing is the better. Too wide a spacing can result in sunburned fruits because of poor vine coverage.

The cantaloupe is deep-rooted but the soil may need to be refilled by rain or irrigation several times in the season. An adequate

supply of moisture is especially important as the late fruit set and develop.

Cultivation should be shallow to avoid injury to the roots. After the vines partly cover the ground, tillage should cease. Any large weeds which develop can be pulled by hand. Injuring, pruning or nipping the vines should be avoided.

Varieties.—Not all of the varieties that are adapted to long-distant shipping are of the high quality which would justify their production for the home or the local market. Knight and Jenny Lind are early green-fleshed melons. Golden Champlain and Emerald Gem are early salmon-fleshed varieties. Honey Rock, Bender Surprise, Hearts of Gold, Pride of Wisconsin, and Burrell Gem are later maturing good quality melons. Crenshaw is adapted to the West. In the South, Smith's Perfect is popular. Delicious, Delicious 51—a fusarium resistant strain—and Golden Delight are good for local market use in the Northeast.

Persian and Baby Persian are very late maturing varieties used in California. The varieties used most in the major shipping districts stem from Hale's Best. Among these are Hale's Best 36 and Hale's Best 936. Powdery Mildew Resistant 45 and the double resistant strains 5 and 6 are important. Texas Aphis Resistant No. 1 and Sulphur Resistant 91 have special uses.

Harvesting.—In order to get highest quality the fruits should ripen on the vine. If the flesh becomes too soft they will not handle well, so harvesting for shipment takes place somewhat before maturity. When the stem separates readily from the fruit under a moderate pressure from the thumb, and leaves a circular depression, the "full slip" or ripe stage has been reached. If only one-half of the stem tears loose the stage of development is referred to as "half slip." Other external characteristics which denote the approach of ripening are the increase in the corky netting in those varieties which develop this condition, and the yellowing of the green color of the skin. Fruit from a dead vine is likely to be tasteless.

Cantaloupes are subject to chilling injury if held very long below 40° F. Full-slip fruits are shipped at 40 to 45° F. temperatures while those which are less ripe move in transit at 50° F. so that they will have better market quality when they reach their destination.

An acre yields about 150 bushels or crates on the average.

Insects and Diseases.—Those described for cucumbers are found on this crop also. *Powdery mildew* is combatted by planting varieties resistant to the disease, or by using a variety like SR 91, the foliage of which will not be damaged by the application of sulphur to control the mildew. Karathane, as a dust or spray, has given good control in some areas.

Winter Melon.

(Cucumis melo var. inodorus.)

A long season of growth (one hundred and fifty days) with a high temperature and low humidity are required for this melon which is lacking in the musky odor of those discussed above.

The method of culture is similar to that of the muskmelon. There are two main types. One includes Honey Dew which is large, and Honey Ball which is small. These are whitish-skinned varieties with or without some netting. The other is typified by the Golden Beauty Casaba which has deep furrows and a tough rind. It can be held longer in storage at 50 to 55° F. than can the Honey Dew type. The winter melons are of best eating quality when the flesh just begins to soften.

Watermelon.

(Citrullus vulgaris.)

Africa is thought to be the native habitat of this vine crop. Its culture is rather old. The ancients' reference to "melons" may have meant the watermelon. A long, warm season for growth is a requisite for successful culture, but early varieties started under glass can be brought to maturity in the North. The germination of watermelon seed is slow and poor at soil temperatures below 70° F.

Fig. 83.–Watermelons about ready for harvest. The deeply cut foliage can be seen. (Boyle.)

Fertilization.–Sandy loam soils are best, and should contain a good content of organic matter. Neutralization of acidity is not necessary, in fact the vines seem to thrive better on quite acid soil.

Well-rotted manure may be used under the hills. A mixed fertilizer of a 1:2:1 to 1:2:2 ratio such as 10:20:10, 8:16:14, 5:10:10 should be applied at a rate to furnish 20 to 50 pounds of nitrogen. A side dressing of about 25 pounds of nitrogen per acre as the vines begin to run is considered helpful.

Propagation and Culture.—The crop is usually started directly in the field. Paper caps are helpful on the early plantings. The rows are spaced 8 to 12 feet apart. When the hill method is used the seeds are planted or the glass-grown plants set out every 6 to 10 feet in the row and the plants thinned to one or two to the hill depending on the vigor of the variety. When the row is drilled, single plants are left at 6 to 10 foot intervals. One pound of good seed will plant an acre. Cultivation is guided by the same consideration as in the case of muskmelons. Sometimes all but three or four well-shaped fruits on each vine are removed so that these will be more certain to reach a good marketable size.

The watermelon is deep-rooted where soil conditions permit. When the evaporation rate is high and the soil does not contain much available moisture, supplementary irrigation may be required.

Varieties.—Cole's Early or Harris' Earliest, New Hampshire Midget, and Peerless are good early varieties for home and local use. Early Kansas, Klondike, Garrison, Halbert Honey and Kleckley Sweet are later varieties of excellent quality for home use and short distance shipping. Black Diamond or Florida Giant, Tom Watson, Dixie Queen, Stone Mountain and Peacock are used for shipment to distant markets. There are many varieties with resistance to certain diseases that are replacing the old favorites. Among those with resistance to fusarium wilt are Klondike R 7, Blue Ribbon, Hawkesbury, Kleckley Sweet No. 6, Ironsides, Blacklee, and the wilt-resistant strain of Dixie Queen. Fairfax and Charleston Gray have resistance to anthracnose and wilt, while Congo is resistant to anthracnose.

The Citron melon is grown for use in preserves.

Harvesting.—The tests for maturity are not infallible. If the fruits give forth a dull rather than metallic sound when thumped they are usually mature. They should be cool when the test is applied. The color of the white spot where the fruit rests on the ground takes on a yellowish tinge as maturity is approached. The tendril at the place of attachment of the fruit stem and vine usually dries with maturity. If melons are to be used at once, they may be pressed on the side with the hand. A sharp cracking sound denotes maturity.

A knife is used to sever the stem several inches from the fruit. If care is taken to avoid bruises watermelons can be kept in a cool fairly dry place for over a month. Good yields should be 500 or more marketable fruits to the acre.

When loaded in trucks or railroad cars for shipment the pile of watermelons must be well cushioned with straw. Fruits weighing over 20 pounds should not be stacked more than four layers high if of the long type and not over three high for the round-shaped varieties. Lighter fruits may be piled one layer higher in each case. Cross-wise loading results in less breakage than if the melons are placed end to end lengthwise of the car. Varieties with thin rinds or weak flesh are likely to split or burst in handling. They cannot be transported to great distances.

Insects and Diseases.—In addition to the pests described under cucumbers, the watermelon is subject to a *Fusarium Wilt* which is distinguished by the browning of the wood in the stem. The organism can remain in the soil or the seed and also be spread by manure. Rotation, sanitation, seed treatment as for anthracnose and the use of resistant varieties are recommended. *Rotting* of either end of the fruit may appear in the field or after harvest. Avoidance of wounds, dipping the cut stem in starch-copper-sulphate paste, sanitation, rotation, and control of foliage diseases help.

PUMPKIN AND SQUASH

(Cucurbita maxima, C. mixta, C. moschata and C. pepo.)

According to Whitaker and Bohn there is no unanimity in various parts of the world in the use of the words "pumpkin" and "squash" as applied to the different species of Cucurbita. They suggest that the two be separated as to their culinary uses. Pumpkins would be the species of Cucurbita the edible fruits of which are used when ripe as stock food or in pies. Ordinarily the flesh is so coarse and strong in flavor that it not served as a baked vegetable. The squashes would be those Cucurbita species whose fruits might be used raw, or in an immature state, or baked. Therefore a summer squash would be the edible fruit of a Cucurbita used while immature and a winter squash is one with fine-grained, mild-flavored flesh used as food when the fruit is mature, either baked as a table vegetable or in pies.

Crosses have been made between some of these four species though usually with difficulty. There is no immediate effect of the pollen on the quality of the fruit so produced if such crossing should occur naturally. C. pepo and C. moschata will cross readily to produce progeny that are self-fertile and will in turn give viable seeds. Therefore they must be isolated in seed production. When combinations of other species have been made the first generation plants were self-sterile.

The pumpkins and squashes make more rapid growth and thrive at somewhat cooler temperatures than do the melons.

These Cucurbita species are natives of the New World. The Indians ate certain types of them several thousand years before Christ.

Fertilization.—The summer or bush types are grown on lighter soils than the later varieties. Fertilizing materials are supplied as for the other vine crops.

Propagation and Culture.—Early types may be started under glass, but this expense is seldom justified with others. Bush varieties are spaced 3 by 4 or 5 feet in hills or drills, and those which vine are given 8 by 8 to 10 by 12 feet if in hills or 3 to 4 feet in rows 8

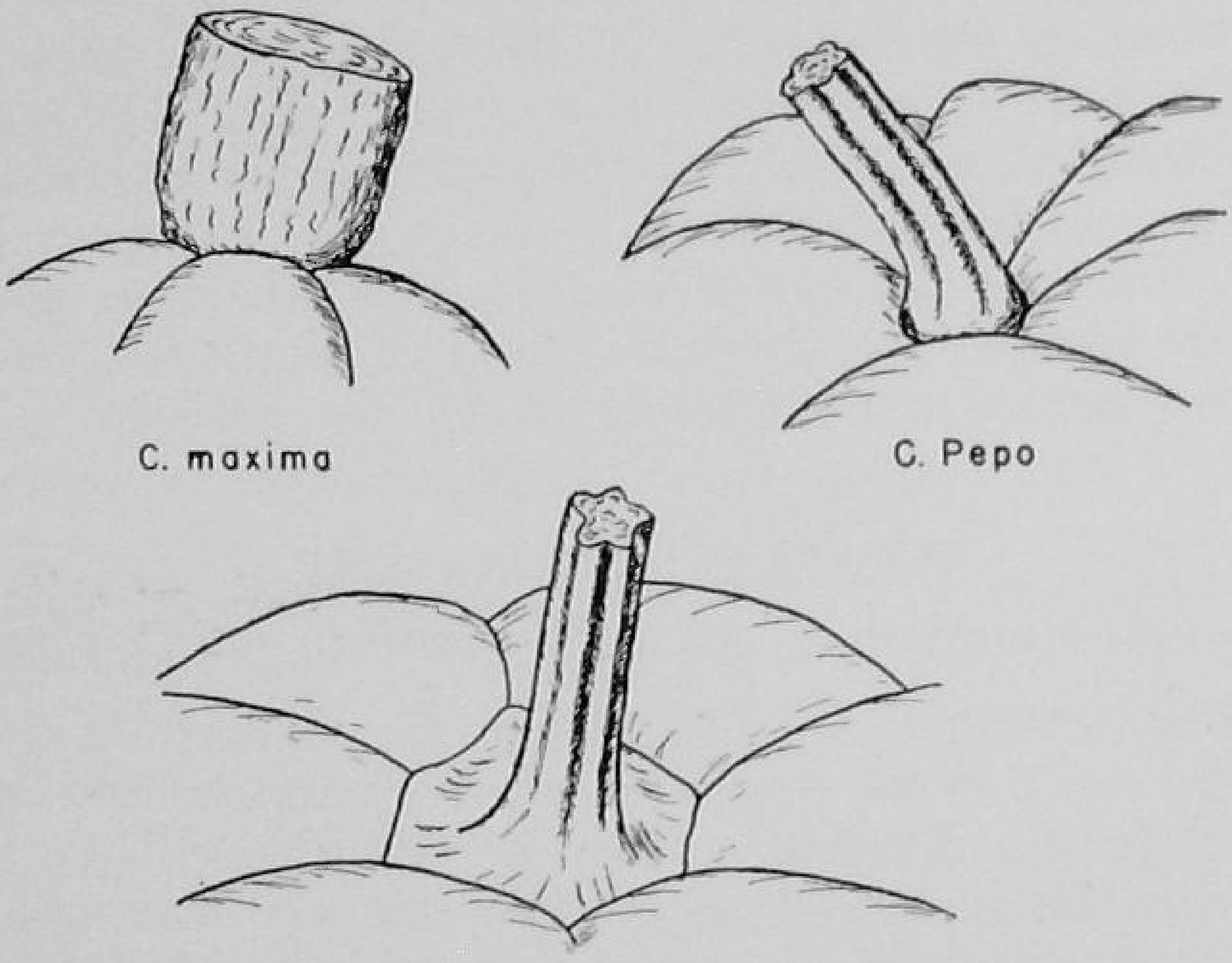

FIG. 84.—Characteristic peduncles or fruit-stalks of the Cucurbita species. The peduncles of C. Mixta resemble those of C. pepo except that they are enlarged by hard cork.

to 10 feet apart. They may be grown as an intercrop with corn. The root systems are very widespread so cultivation must be shallow. Summer squashes root to a moderate depth while the vining types of pumpkins and squash are deep rooted. Under some conditions water may have to be applied to refill the rooting zone and maintain a vigorous growth.

Varieties.—Three general groupings of the varieties can be made according to their use.

Summer Squash.—

C. pepo. Patty Pan or White Bush Scallop; Green Tint Scallop; Yellow Bush Scallop or Golden Custard; Golden Summer Crookneck; Giant Summer Crookneck; Early Prolific Straightneck; Giant Summer Straightneck; the English Marrow group—White Bush, White Vining, Green Bush, Green Vining; the Italian Marrow

group—Caserta, Zucchini, Cocozelle, Cosini. Yankee Hybrid, of the Straightneck type, and Storrs Green Hybrid, of the Zucchini type, are F_1 hybrids.

Pumpkin.—

C. pepo. Connecticut Field; Small Sugar; Winter Luxury.

C. mixta. Japanese Pie; Tennessee Sweet Potato; White Cushaw; Green Striped Cushaw.

C. moschata. Kentucky Field or Large Cheese; Dickinson.

C. maxima. Mammoth Chili or King of the Mammoths with giant-sized fruits used in exhibits and for stock feed.

Winter Squash.—

C. pepo. Table Queen, Des Moines or Acorn; Golden Table Queen.

C. moschata. Butternut.

C. maxima. Hubbard, Green, Blue, Golden and Warted; Delicious, Green and Golden; Boston Marrow; Banana, Pink, Blue and Orange; Buttercup; Marblehead; Turban.

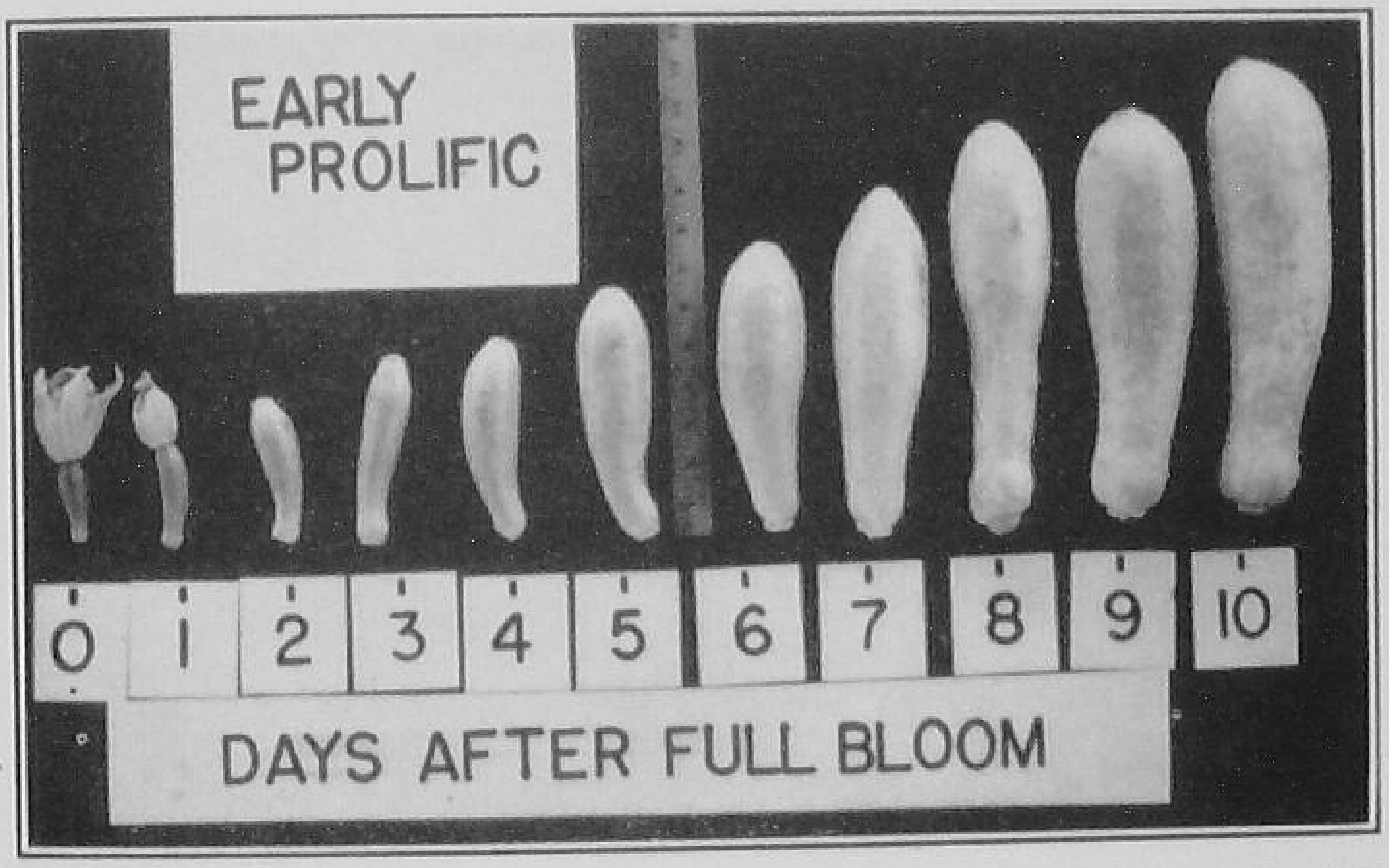

FIG. 85.—Rate of development of Early Prolific Straightneck Squash. (Courtesy California Agr. Exp. Sta.)

Harvesting and Storing.—The summer types should be immature when harvested. In the West they are cut from the vines four to six days after the blossoms open, while elsewhere it is more common to permit the fruits to develop for six to nine days before harvesting. If any fruits are allowed to mature on the vine the number and development of later fruits will be reduced.

Summer squash fruits are susceptible to chilling injury in the same temperature range as are cucumbers. An acre should yield about 400 bushels (45 pounds each).

Winter varieties are allowed to become fully matured as increased keeping quality is obtained. The fruits are cut from the vines just before frost in the fall. The shell should be hard for successful storage. They must be handled carefully in the move from the field to the storage place to avoid bruising or breaking the surface. Rots will spread less readily if the fruits are placed on shelves in a single layer not touching one another. Storage houses are usually of the above-ground type with insulated walls and some means of heating. Too high a temperature results in great shrinkage. About 55° to 60° F. with a relative humidity of 50 to 70 per cent should provide satisfactory storage life.

Yields should average between 10 and 20 tons to the acre.

Insects and Diseases.—Those described for the cucumber are often found on these crops. Some of the insects prefer the pumpkins and squash to any of the other vine crops.

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Chapter 30

SWEET CORN

SWEET CORN.

(Zea mays var. rugosa.)

THE first mention of sweet corn was in 1779, when it was found among the Indians along the Susquehanna river. Warm days and nights with plenty of sunshine favor the rapid growth of corn. High temperature as the corn reaches the edible stage is responsible also for a rapid loss of quality.

In the southern states the true sweet corn is known as "sugar corn" while varieties of field corn harvested in the immature stage are called "sweet corn."

Fertilization.—The early crop which is the one that sells at the highest price makes rapid growth on a well-drained sandy loam soil. The heavier classes of soil are better for the later plantings. Manure is valuable but can be replaced with green manures and commercial fertilizers. On a sandy loam soil, corn should have 30 to 60 pounds of nitrogen and about twice that much phosphoric acid and potash depending on the fertility of the soil and how early the crop is planted. The fertilizer used on a heavier soil for a later planted crop need only furnish 20 to 30 pounds each of nitrogen and potash along with 60 to 120 pounds of phosphoric acid, as in a 4:12:8 or 5:10:5 analysis. In the Middle West a 1:4:4 ratio is used at a rate to supply 20 to 30 pounds of nitrogen to the acre.

For the winter plantings in the desert areas of California 160 pounds of nitrogen per acre is recommended. Sweet corn grown in other seasons in that state responds to only 80 to 100 pounds of nitrogen an acre. On some soils the nitrogen is accompanied by an acre application of 100 pounds of phosphoric acid.

When 500 pounds or less of fertilizer are used on an acre it is best to place this in bands about 2 inches on each side of the seeded row and perhaps an inch deeper than the seed.

It is desirable to side dress corn when it is about knee high with 30 pounds of nitrogen to the acre. Sometimes an earlier application is needed.

Sweet corn for freezing or canning is often grown as part of a general rotation. Here 10 or 15 tons of manure may be used and supplemented with 500 pounds of superphosphate only.

Propagation and Culture.—Plants can be started under glass in containers and shifted to the garden but the cost is seldom justified commercially. If the seeds are treated with organic mercury dust the danger of rotting in cool soil is reduced. It takes ¼ teaspoon of Semesan Jr per pound or 3½ ounces per 100 pounds of seed. Arasan, Barbak C and Spergon can be used at a somewhat lesser rate.

Sweet corn is a tender, warm-season crop but it will withstand light frosts. Usually the soil will be warm enough to germinate the seed about the time of the last killing frost. Naturally germination will be better and quicker when the soil is warmer. Early plantings should be made at a depth of ½ to 1 inch where the soil will be warmed by the sun, while later plantings can be made at a 1 to 2 inch depth. In many parts of the country the first corn to reach the market brings the best price. Therefore it is worthwhile to chance a planting at the average date for the last killing frost. A good stand of plants will usually result in an increased yield. Seed treatment and the use of a greater quantity of seed in the early plantings than would be used in later plantings will help ensure a good stand. There is considerable variation in the size of the seed kernels between the different varieties so it may take more weight of seed of one variety than of another to get the same stand. Two lots of the same variety will differ in seed size. It takes 6 to 12 pounds of seed to plant an acre. The planter should be carefully adjusted to drop the desired number of seeds per foot of row so that there will be a choice of plants if they are to be thinned to a certain spacing. It is possible to obtain from some seedsmen sweet corn seed that has been sized and is to be planted with a specific plate on the seed drill.

Successive plantings of an early variety or simultaneous planting of early, mid-season and late varieties are possibilities. If successive plantings are made at intervals of two weeks during the spring, they will about overlap at maturity and provide a continous supply of ears. Cultivation in two directions is possible when the plants stand in hills, and although hand work is reduced, the yield is usually less than in drills where the plants have more room for development. From 5 to 8 seeds are placed in hills and the number of seedlings reduced to 3 or 4. The spacing of the hills depends upon the size of plant produced and ranges from 2½ by 2½ to 3½ by 3½ feet. Drills are placed 2½ to 3½ feet apart, and a plant left every 8 to 15 inches. The early types can be planted in closer rows and spaced more closely in the row than can the later ones which make larger plants. When furrow irrigation is practised the corn is necessarily drilled in rows. If the corn is planted on sloping land the drill method is preferred to the hill system, because should cultivation be practised up and down the slope, there is great danger of erosion. The drill method may give a slightly larger yield than the hill

method. This may be owing to the better distribution of the plants and the more efficient tapping of the soil for water and nutrients. If close spacing, 3 square feet or less per plant, is practiced one must be certain that heavy fertilization has been given and that provision is made for an adequate supply of moisture.

In order to ensure proper pollination it is desirable that at least 3 rows be planted beside one another at each planting. It is best in the home garden to plant 3 or more short rows at one time rather than 1 row the whole length of the garden. Machine and hand planters can be used for placing the seed in the ground.

Weeds must be controlled, but the operation of cultivation should be as shallow as possible in order to avoid injury to the root system. Just before the corn comes through the ground, it is possible to kill the early weeds by using a weeder, rotary hoe, or even a spike-tooth harrow set shallowly.

It is practical to use a dinitro amine spray just before the corn emerges at a rate of 3 to 6 pounds of the actual ingredient per acre in 25 or more gallons of water The amine salt of 2,4-D can be applied once at $\frac{1}{4}$ to $\frac{1}{2}$ pound an acre when corn is 6 to 12 inches high and weeds need killing. Drop pipes are used on the sprayer to keep the chemical off of the leaves. Some of the early varieties are subject to 2,4-D injury. Most agricultural colleges are prepared to supply recommendations for local conditions.

Not enough corn roots penetrate the soil to the deeper layers where moisture is available. Thus rains or irrigation must keep a supply of moisture in the surface foot if growth is to be unrestricted. A lack of water is indicated by the inward rolling of the edges of the leaves.

Certain varieties produce more "suckers" or tillers at the base of the main stalk than do others. Sometimes these produce "nubbin" ears. Experiments in many states indicate that in general there is not enough gain in earliness, size or yield to justify the expense of removing these "suckers." The practice may even be injurious.

Varieties.—The old standard varieties such as Golden Bantam, Whipples Early Yellow, Country Gentleman and Stowells Evergreen whose seed is produced by natural cross fertilization in the field (open pollination) are still grown to some extent. However, since the introduction of the hybrid, Golden Cross, there has been a rapid shift to the use of hybrids. The advantages of the hybrids over the older varieties are great vigor, evenness of growth and maturity, and high productivity of uniformly sized ears combined in some cases with resistance to Stewart's disease or bacterial wilt.

Several sorts of crossed corn are sold by seedsmen, so it is important to be certain of what one is buying. A row of the pollen parent is alternated with about 4 rows of the female or seed parent.

All the plants in these latter rows must be detasseled. The value of crossed corn seed depends entirely on the thoroughness with which the seed grower has done his work. Many of the hybrids offered are first generation crosses (F_1) of two inbred lines. The cross must be made each year. It is useless to save seed from a planting of an F_1 hybrid because the next generation is likely to segregate into a number of types. Top-crossed seed is the result of an inbred line crossed with an ordinary stock. It is almost as good as the F_1 hybrid-inbreds and has larger seed. Double-crossed stocks are obtained by crossing two pairs of inbred stocks and then crossing the progeny.

FIG. 86.—Harvesting the ears of sweet corn mechanically for a processing plant. This machine does the work of ten men picking by hand. (Courtesy of Food Machinery Corporation.)

The seed of these crossed corns is more expensive than the open-pollinated stocks because of the work involved in their production. However, since the seed is much smaller, less weight of seed is needed to plant an acre than with the open-pollinated varieties.

The stocks of Golden Cross type differ materially between seedsmen. There have been improvements on the original, as well as many new hybrids. Thus the grower has a choice of innumerable hybrid sweet corns to fill his particular needs.

Great emphasis has been placed on the earliness of sweet corn varieties because of the desirability of attaining the early market with its high price. New hybrids are appearing constantly as a result of extensive breeding work underway throughout the country.

Among the hybrids, Spancross and Seneca Dawn are very quick-

maturing, followed a few days later by Marcross, Seneca Golden, ForeMost Y-1, and Carmelcross. Slightly slower than these in reaching the edible stage are Golden Cross Bantam, Seneca Chief, Ioana, Calumet, Illinois Golden 10, and Iochief.

Aristogold Bantam and Aristogold Bantam Evergreen are slow maturing golden F_1 hybrids which are popular in the South because they are somewhat resistant to corn ear worm attacks. There is an open-pollinated variety, Honey June, which is extensively used in the South. This is a white, semi-sweet corn with tight husks on the ears which help keep out the ear worms.

Harvesting.—A downward twisting jerk will usually snap the ear from the stalk. Sweet corn should be pulled in the milk stage, that is when a milk-like juice exudes from the kernels if these are crushed with the thumb nail. Some varieties pass rather quickly through the milk stage into the dough condition. A dried silk and well-filled husk are the external signs which identify a properly developed ear, but stripping back the husk may be desirable if one is in doubt.

Various types of equipment are used to reduce the labor costs of harvesting sweet corn. Very high clearance carts or trucks into which the ears are tossed by the pickers can move over the plants injuring them so slightly that subsequent harvests are possible. In Florida a veritable travelling packing house moves down the rows. The ears are placed by the pickers on conveyers which carry them to the packers on a platform who fill the crates.

Corn harvesters are used for picking corn designed for processing. The stalks are drawn through the machine as it moves down the row. The ears are forced loose and move over into a truck being driven parallel to the harvester. The slight degree of injury produced on the ears by this method is not objectionable in processed corn.

The method of handling the corn after harvest is of great importance. If the ears are piled or placed in gunny sacks the respiration of the green tissue will raise the temperature above that of the surrounding air. At about 85° F. one-half the sugar will be changed to starch in the first twenty-four hours. Immediate processing or cooking will enable one to obtain the highest quality. If corn must be held for sale the temperature of corn itself should be at or near 32° F. Package icing after precooling is the only practical way to attain this condition. Even so the corn will retain good eating quality for only about seven days. Crates or wet-strength paper bags holding 4 or 5 dozen ears and 20 to 25 pounds of crushed ice can be used.

When the husks are removed and the ears packaged in cellophane some of the heating is avoided. Here also every precaution must be taken to cool the corn quickly to 32° F. and hold it there or the quality will soon be lost.

An acre should yield 500 to 1000 dozen ears.

Heat Units.—The degree-day system described under Pea is being employed with some success for scheduling the plantings of sweet corn for processing. The base temperature that is subtracted from the daily mean temperature is 50° F. in the case of sweet corn. The early varieties require about 1500 compared to about 2000 degree-days for the late varieties.

Insects and Diseases.—The *European Corn Borer* attacks many other vegetables besides corn. Its control is discussed in Chapter 13. The *Corn Earworm* is often mistaken for the borer. It is one of the factors limiting sweet corn production in the South. The mature larvae are about 1½ inches long of various shadings from green to brown with or without stripes or spots along the sides. They devour the silk and kernels near the tip. Varieties with tight husks like Honey June used in the South suffer less damage. One can eliminate most of the worms by clipping off the silks together with the tip ½ inch of the husks 3 to 4 days after most of the silks have appeared. The clippings should be destroyed. The injection of 15 drops (½ to ¾ of a cubic centimeter) of light U.S.P. mineral oil containing 0.2 per cent of pyrethrins, 1 per cent DDT, or 2 per cent dichloroethyl ether is a fairly effective method. The oil is forced into the silks by means of an oil can with a trigger attachment. The treatment is given the third or fourth day after the silks appear or about as they begin to wilt. This allows time for pollination to take place and yet the larvae will not have reached the kernels.

One can coat the silks with a duster or by hand with a stencil brush. A 5 or 10 per cent DDT dust is used three times at two or three day intervals beginning as the silks first appear. It takes 30 to 40 pounds per acre. A spray consisting of 3 quarts of 25 per cent emulsifiable DDT and 2½ gallons of light mineral oil diluted with water to make the 25 gallons needed per acre is effective also.

Corn Smut is the commonest disease on sweet corn. The affected part of the plant puffs out and then produces a copious supply of black spores. These can remain in the soil for at least eight years. No very effective control measures are available. Rotation, use of clean manure, burning of the diseased parts before the spores are discharged will help. Use of resistant strains appears to be a possible method of the future. *Seedling Blights,* which are responsible for the apparently poor germination of early sowings in particular and which may appear later as root, stalk or ear rots, can be checked by dusting the seeds before planting with organic mercury dusts. Seed selection and seed testing as well as proper fertility of the soil play an important part in controlling these troubles. *Bacterial Wilt* or Stewart's Disease is severe in some years. Some of the hybrid varieties are resistant to the disease. Wilt is spread by

flea beetles. The weekly use of a 5 per cent DDT dust or an equivalent spray beginning as soon as the beetles are first noted will help control them. In some sections of the country it is necessary to follow a systematic program of DDT applications to check beetles, borers, and earworms, commencing when the plants are quite small. Ground rigs and planes are used.

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Chapter 31

MISCELLANEOUS WARM-SEASON CROPS

MARTYNIA.

(Proboscidea jussieui.)

The seed pods of the martynia or unicorn plant are used in pickles when quite young. The plants are spreading with rather attractive purple blossoms. A light, fertile soil is best. The plants may be started under glass in the North about the same time as tomatoes are seeded. A spacing of 2 to 3 feet in rows 3 to 4 feet apart is given.

FIG. 87.—Martynia bears many curved pods.

OKRA.

(Hibiscus esculentus.)

This African vegetable, known also as "Gumbo," is used in stews and soups. It does best in regions with a long warm season for

growth, but if started under glass in the North will produce a fair crop of pods. A fertile, sandy loam will give good development without much additional fertilizer except some superphosphate. On poorer soil 10 to 20 tons of manure or 500 to 1000 pounds of 5:10:5 fertilizer are recommended. The planting distance is 12 to 18 inches in rows about 3 to 4 feet apart.

FIG. 88.—Top of an okra plant showing unopened buds, a blossom, small pods, two pods ready for harvest, and below them the stems from which pods have already been harvested. (Courtesy of California Agr. Exp. Sta.)

Dwarf and tall types with short and long pods are available. Clemson Spineless, White Velvet, Perkins Spineless, Emerald and Louisiana Green Velvet are good varieties.

The seed pods are harvested every other day in the height of the season. The young pods are tender but soon become tough and

woody if left on the plant or if not used soon after harvest. The growth and productivity of the plant is reduced when pods are permitted to mature seed. In the South yields of 3 to 5 tons an acre can be obtained. The quick freezing of okra has stimulated production.

Wilt fungi which persist in the soil can best be avoided by rotation.

ROSELLE

(Hibiscus sabdariffa)

This annual, known also as "Jamaica sorrel" and "Florida cranberry," is adapted to the most southern parts only of the United States. It is very sensitive to frost. A season of five to six months from seeding to harvesting is required.

Plants can be started in flats or nursery beds, and potted like eggplants for later setting in the field. Direct seedings in the field are made after the soil has become warm. Three pounds of seed are used to the acre. The rows are spaced 5 to 6 feet apart with the plants set out or thinned to stand 2½ feet apart in the row. Some growers set the plants at a 4 by 4 foot spacing. The plants should not be grown in too rich a soil nor should they be fertilized too heavily with nitrogen as these conditions may delay maturity.

The large flowers appearing in October give rise in three or four weeks to the swollen red calyces and bracts that constitute the fruits. These are broken off before the tissues become woody. A well-developed plant may produce as much as 15 pounds. The fruits are marketed in quart baskets. The principal use is in jelly and jam.

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